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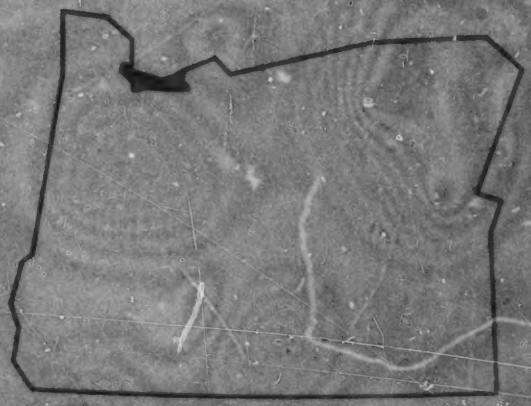
FLOOD INSURANCE STUDY

ORIGINAL

MULTNOMAH COUNTY, OREGON
UNINCORPORATED AREAS



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Federal Emergency Management Agency

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TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
1.1	Purpose of Study	1
1.2	Authority and Acknowledgments	1
1.3	Coordination	1
2.0	AREA STUDIED	2
2.1	Scope of Study	2
2.2	Community Description	6
2.3	Principal Flood Problems	9
2.4	Flood Protection Measures	15
3.0	ENGINEERING METHODS	17
3.1	Hydrologic Analyses	17
3.2	Hydraulic Analyses	20
4.0	FLOOD PLAIN MANAGEMENT APPLICATIONS	23
4.1	Flood Boundaries	23
4.2	Floodways	24
5.0	INSURANCE APPLICATION	32
5.1	Reach Determinations	32
5.2	Flood Hazard Factors	32
5.3	Flood Insurance Zones	32
5.4	Flood Insurance Rate Map Description	35
6.0	OTHER STUDIES	36
7.0	LOCATION OF DATA	36
8.0	BIBLIOGRAPHY AND REFERENCES	37

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TABLE OF CONTENTS (Cont'd)

Page

FIGURES

Figure 1 - Vicinity Map..... 3
Figure 2 - Historic Flooding..... 11
Figure 3 - Historic Flooding..... 12
Figure 4 - Historic Flooding..... 13
Figure 5 - Historic Flooding..... 14
Figure 6 - Floodway Schematic..... 25

TABLES

Table 1 - Detailed-Study Streams..... 4
Table 2 - Approximate-Study Streams..... 5
Table 3 - Regulatory Effect of Flood-Control Reservoirs..... 16
Table 4 - Summary of Discharges..... 19
Table 5 - Summary of Elevations..... 21
Table 6 - Floodway Data..... 26
Table 7 - Flood Insurance Zone Data..... 33

EXHIBITS

Exhibit 1 - Flood Profiles

Columbia River	Panels 01P-06P
Willamette River	Panels 07P-08P
Multnomah Channel	Panels 09P-10P
Sandy River	Panels 11P-19P
Johnson Creek	Panels 20P-31P
Fairview Creek	Panels 32P-33P
Unnamed Tributary to Rock Creek	Panel 34P

Exhibit 2 - Flood Boundary and Floodway Map Index
Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map Index
Flood Insurance Rate Map

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1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study has been prepared to revise and update a previous Flood Insurance Study/Flood Insurance Rate Map for the unincorporated areas of Multnomah County, Oregon. This information will be used by Multnomah County to update existing flood plain regulations as part of the regular program of flood insurance by the Federal Emergency Management Agency (FEMA). The information will also be used by local and regional planners to further promote sound land use and flood plain development.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by the U.S. Army Corps of Engineers (COE), Portland District, for FEMA, under Inter-Agency Agreement Nos. IAA-H-16-75, IAA-H-7-76, and IAA-H-10-77, Project Order Nos. 14, 1, and 23, respectively. This study was completed in July 1980.

Hydraulic analyses for Johnson Creek were revised in January 1983 by the COE, Portland District, to reflect channel improvements between River Miles 6.8 and 7.3. Hydrologic analyses within Multnomah County Drainage District No. 1 were revised in a July 1984 report entitled Multnomah Drainage District No. 1 Hydrology Study (Reference 1).

1.3 Coordination

The initial coordination meeting was held on November 8, 1974, and was attended by county officials and representatives of FEMA, the U.S. Soil Conservation Service (SCS), the study contractor, and the Oregon Water Resources Board. At that meeting, the limits of approximate and detailed studies were determined. In addition, flood problems and necessary land-use measures to be adopted upon completion of the study were discussed.

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Preliminary flood plain maps and flood profiles were furnished to Multnomah County for use in preparing the county's comprehensive plan. Discharges derived for Fairview Creek were furnished to Multnomah County for use in analyzing a potential development along the stream. Available topographic maps and elevation reference marks were furnished by the City of Portland, Multnomah County, and the Port of Portland. Drawings of Willamette River and Columbia River bridges were furnished by Multnomah County, Oregon State Highway Department, and Burlington Northern, Inc.

An intermediate coordination meeting was held on May 13, 1979, and was attended by representatives of FEMA, the study contractor, and Multnomah County. At that meeting, work maps showing water-surface profiles, floodway limits, and flooded areas were presented by the study contractor for review by county officials. The FEMA representative discussed the status of Multnomah County in the conversion from the Emergency Phase to the Regular Phase of the National Flood Insurance Program (NFIP).

A final community coordination meeting was held on July 20, 1981, and was attended by representatives of FEMA, the study contractor, and the county. No problems were raised at the meeting.

This study was revised in 1984 to include channel improvements along Johnson Creek, reflect new hydrologic analyses within Multnomah County Drainage District No. 1, conform to FEMA levee policy, and update corporate limits and cultural features.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the unincorporated areas of Multnomah County, Oregon. The area of study is shown on the Vicinity Map (Figure 1).

Not included in this study are the Cities of Fairview, Gresham, Maywood Park, Milwaukie, Lake Oswego, Portland, Troutdale, and Wood Village.

The streams studied by detailed methods are shown in Table 1.

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through 1989.

The streams studied by approximate methods are shown in Table 2.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and

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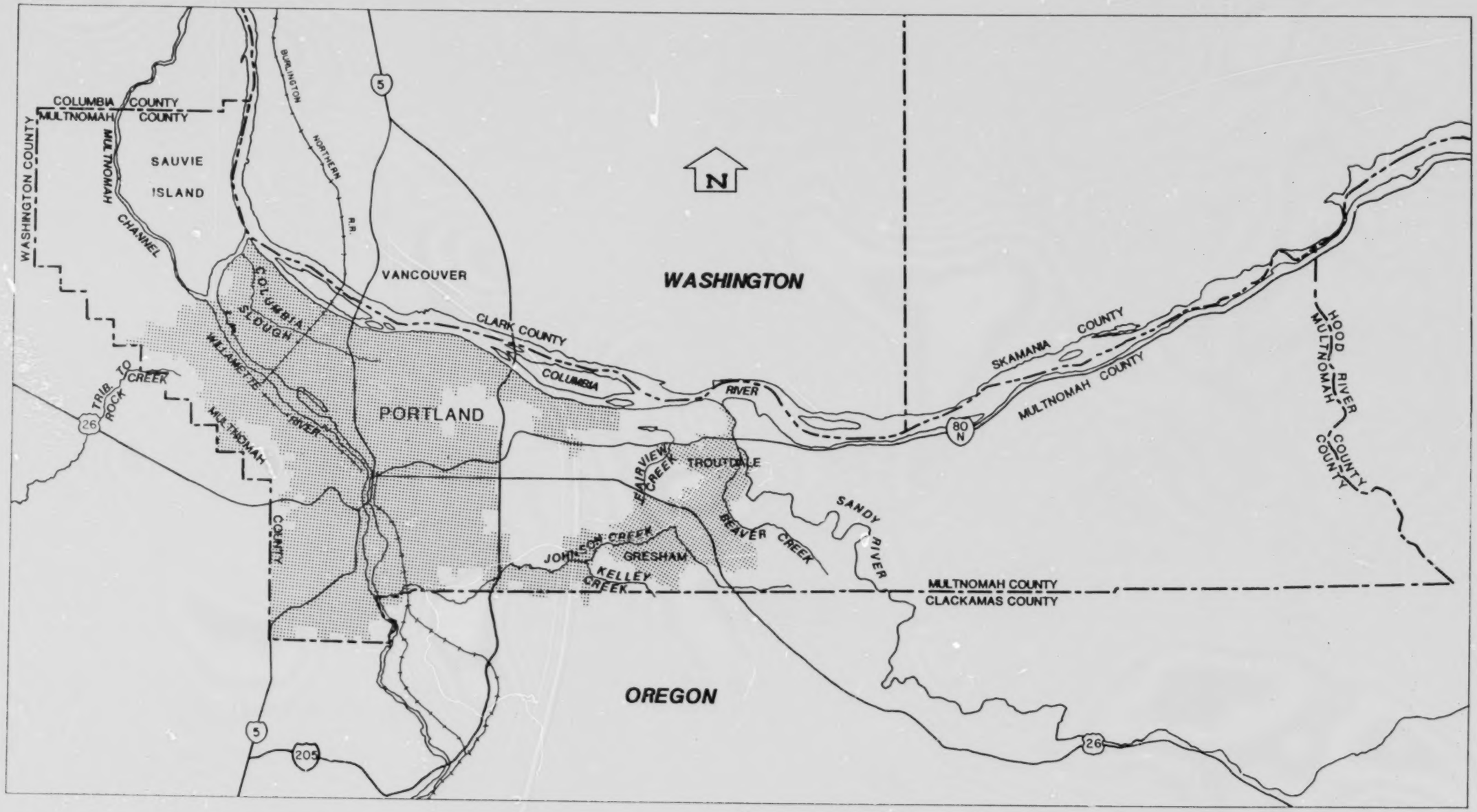

APPROXIMATE SCALE
0 4 8 12 MILES

VICINITY MAP

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH COUNTY, OR
(UNINCORPORATED AREAS)

FIGURE 1

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Table 1. Detailed-Study Streams

Drainage	Study Limits
Columbia River	From the Multnomah-Columbia County boundary to River Mile 125.5
Willamette River	From its mouth to the Multnomah-Clackamas County boundary
Sandy River	From its mouth to Dabney State Park
Multnomah Channel	From the Multnomah-Columbia County boundary to its divergence from Willamette River
Johnson Creek	From the Multnomah-Clackamas County boundary near 82nd Avenue to the unincorporated community of Pleasant Home
Fairview Creek	From the Fairview corporate limits to Glisan Street and from midway between Glisan and Stark Streets to Burnside Street
Unnamed Tributary to Rock Creek	From the Multnomah-Washington County boundary near Germantown Road to a point approximately 0.5 mile east
Columbia Slough	From its mouth to North Portland Road
Ponding	Within Multnomah Drainage District No. 1

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Table 2. Approximate-Study Streams

Drainage	Study Limits
Columbia River	From the limit of detailed study to the Multnomah-Hood River County boundary
Sandy River	From Dabney State Park to the Multnomah-Clackamas County boundary
Peninsula Drainage Canal	
Beaver Creek	From the Troutdale corporate limits to the Gresham corporate limits
Fairview Creek	From the Fairview corporate limits to Glisan Street and from midway between Glisan and Stark Streets to Burnside Street
Kelley Creek	From its confluence with Johnson Creek near 162nd Avenue to 190th Avenue
Mitchell Creek	From its confluence with Kelley Creek to approximately 700 feet upstream of Baxter Road
Small drainage area upstream of Kaiser Road	From approximately 600 feet upstream of its confluence with Unnamed Tributary to Rock Creek to its mouth

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methods of study were proposed to, and agreed upon by, FEMA and Multnomah County.

2.2 Community Description

Multnomah County is in northwestern Oregon. It is bounded by Columbia River on the north, by the Tualatin Mountains on the west, and by the Cascade Mountain Range on the east. Along the southern county boundary, Johnson Creek flows westerly to Willamette River. Willamette River, as it flows northerly through Portland to join Columbia River, bisects western Multnomah County.

Multnomah County is bordered by Clark County, Washington, to the north, Skamania County, Washington, to the northeast, Hood River County to the east, Clackamas County to the south, Washington County to the west, and Columbia County to the northwest. Encompassing nearly all of the Portland metropolitan area in its approximately 460 square miles, Multnomah County is the most populated and developed county in Oregon.

Since establishment of the county in 1854, its population has grown rapidly, from 338,241 in 1930 to 522,813 in 1960 (Reference 2). In recent years, the growth rate has slowed; in 1978, the population was estimated at 549,000 (Reference 3). Most of that population resides in Portland and its adjacent communities within the Willamette Valley of western Multnomah County. Eastern Multnomah County is sparsely settled. Portland, the county seat and the largest city in Multnomah County, had an estimated 1979 population of 366,650 (Reference 3).

Columbia, Willamette, and Sandy Rivers are the largest rivers in Multnomah County. Columbia River, with its headwaters on the western slope of the Continental Divide in southwestern Canada, drains approximately 241,000 square miles. The basin terrain varies from steep mountain slopes to gently rolling farmland. Willamette and Sandy Rivers, with drainage areas of 11,200 and 502 square miles, respectively, have their origin on the western slope of the Cascade Mountain Range. Willamette River originates in a steep, timbered, mountainous watershed and flows through the flat, wide, agricultural Willamette Valley for 185 miles to its mouth. Willamette River passes through Portland approximately 3 miles upstream of its confluence with Columbia River. Sandy River emerges from melting glaciers on Mount Hood, and then follows a steep and timbered valley until it meets Columbia River near Troutdale.

Flood plain development varies widely along Columbia River in the unincorporated portions of Multnomah County. Scenic Columbia River Gorge, upstream of Sandy River, is sparsely developed. From downstream of Sandy River to the Burlington Northern Railroad bridge, the south bank of the Columbia River has a broad flood plain protected by levee systems. Within those levee systems are agricul-

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tural lands, with scattered industrial, commercial, and residential development. South of Columbia River, between the Burlington Northern Railroad and Willamette River, is Rivergate Industrial District, a recent development on dredged fill material that elevates previously low-lying land above expected flood levels. Farther downstream, Sauvie Island is bounded by Willamette River, Multnomah Channel, and Columbia River. The island is agricultural bottom land; most of the area is protected by levees.

The unincorporated portion of the Willamette River flood plain in Multnomah County extends upstream and downstream of the City of Portland. Flood plain development upstream of Portland is limited to residences along a narrow 2-mile-long strip on the west riverbank. The downstream portion is a 3-mile stretch, with the Sauvie Island perimeter levee on the west bank and the elevated Rivergate Industrial District on the east bank.

There are only a few homes and small businesses located along the riverbanks of Sandy River immediately upstream of the Troutdale corporate limits. But, because of its nearness to the Portland metropolitan area, it has considerable development potential. Farther upstream, much of the river is within a forested canyon with moderately steep sides and a small flood-prone area. Downstream of the Troutdale corporate limits, there is no development within the flood plain.

Johnson Creek flows westerly for approximately 23 miles in southern Multnomah County and enters Willamette River at the county's southern boundary. The Johnson Creek flood plain is heavily developed in the study area between the corporate limits of Portland and Gresham. A wide flood-prone area extending from 100th Avenue to 136th Avenue and as far north of Johnson Creek as Holgate Boulevard includes many homes and some industries and warehouses. Upstream of Gresham, residences are scattered along the stream.

Columbia Slough enters Willamette River near its confluence with Columbia River in Portland. High-water levels in the slough and surrounding area are caused by Willamette River backwater. The detailed-study area within the unincorporated portions of Multnomah County is west of North Portland Road and almost entirely within the growing Rivergate Industrial District. Historically, the flood risk in that area has been too great to attract much development. Therefore, the bordering lowlands are still open for future land-use considerations.

Multnomah Channel is a natural bypass channel for Willamette River to Columbia River. The channel leaves Willamette River approximately 3 miles upstream of the mouth of Willamette River and travels northerly along the west side of Sauvie Island for approximately 20 miles to its confluence with Columbia River. The portion of Multnomah Channel within unincorporated Multnomah County has limited development.

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Houseboats, several boat moorages, a marina, and a golf course are in the flood plain. Because of its proximity to Portland and major transportation routes, future flood plain development is probable.

Fairview Creek flows northerly from its source near Grants Butte, through the populated suburban area east of Portland, and empties into Fairview Lake near Columbia River. It drains rolling pasture-land interspersed with residential subdivisions. Fairview Creek has been channelized through a large subdivision between Burnside Road and Stark Street. South of the City of Fairview, the stream slopes gently as it passes through a thickly wooded area where a large planned-community development is under construction.

Beaver Creek, a tributary to Sandy River, flows northerly in a canyon with steep and forested side slopes. Because of the steep terrain, only a few areas are suitable for development within the Beaver Creek flood plain.

Kelley Creek enters Johnson Creek at 160th Avenue from low hills south of Johnson Creek. It drains an area of rolling farmlands with scattered residences. Mitchell Creek flows into Kelley Creek approximately 900 feet downstream of the Kelley Creek crossing of Foster Road.

The only stream studied west of Willamette River is Unnamed Tributary to Rock Creek, which is within the Tualatin River drainage basin. That stream flows from the steep and forested slopes of the low Tualatin Range and enters the flat pastured area of the study area south of Germantown Road. There is no development in the flood plain except for Kaiser Road. Just upstream of the Kaiser Road crossing, Unnamed Tributary to Rock Creek is joined by a small stream flowing southerly to its confluence.

Multnomah County Drainage District No. 1 fronts Columbia River between approximately 20th Avenue and Fairview Avenue. There is both agricultural and industrial development in its flood plain.

Multnomah County has a temperate climate that is influenced by the Pacific Ocean, which is approximately 70 miles to the west. Summers are dry with pleasant temperatures; in the lower elevations, winters are rainy and mild with a narrow temperature range. Temperatures in Portland range from an average January minimum of 35°F to an average July maximum of 79°F (Reference 4). Near Willamette River, average annual precipitation is approximately 39 inches, with over one-half falling during the months of November through February. From Willamette River toward the east, average annual precipitation increases drastically. In the foothills of the Cascade Mountain Range, over 100 inches have been recorded (Reference 5). Soil drainage characteristics in the eastern portion of the county are generaly good, while they are poor west of Willamette River.

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2.3 Principal Flood Problems

Columbia River flooding in Multnomah County usually occurs in spring, during the Columbia River Basin snowmelt freshet. However, intense winter rainstorms are the primary cause of flooding on the remaining Multnomah County streams, and they occasionally cause Columbia River flooding. Additionally, several localized ponding areas in the county are subject to flooding from seepage through levees during prolonged high Columbia River stages. Intense winter-storm runoff is the primary cause of flooding in the large ponding area along Johnson Creek.

The annual Columbia River snowmelt freshet occurs in May or June and has caused flooding in Portland during high-runoff years. Willamette River floods during the spring freshet primarily as a result of backwater from Columbia River. The June 1894, 1948, and 1956 floods, with recurrence intervals of 80, 48, and 18 years, respectively, were snowmelt freshets. Those flood events had peak discharges at The Dalles, Oregon, the nearest gaging station with a reliable discharge measurement of 1,240,000, 1,010,000, and 823,000 cubic feet per second (cfs), respectively.

Minor flooding in Multnomah County begins when flows at The Dalles reach 450,000 cfs, and major damage begins when flows reach 600,000 cfs.

Multnomah County flood damage from the June 1894 flood, the largest recorded on Columbia River, is not well documented. However, that flood is estimated to have covered the broad, flat area on the south bank of Columbia River from Sandy River to Willamette River below the elevation of approximately 36 feet. Additionally, on Sauvie Island and Hayden Island, only a few isolated knolls were above water. Willamette River, backed up from the high Columbia River stage, caused damage primarily to development in the incorporated area of Portland.

The June 1948 flood, the second largest of record on Columbia River, resulted in Willamette River backwater that crested 12 feet above bankfull stage at the Morrison Street bridge and inundated many riverside establishments. Multnomah County Drainage District No. 1 was flooded when the levee system failed. Flood depths in the drainage district ranged from 10 to 20 feet (Reference 6).

Damage in the unincorporated portion of the district included farm crops, farm buildings, and residences. Sandy Drainage District, which adjoins Multnomah Drainage District No. 1 on the east and extends to Sandy River, was not flooded. However, the aluminum plant within the district suspended operations and provided approximately 600 people for flood fighting (Reference 7). Willamette River flooding downstream of Portland included the site of Oregon Shipbuilding Corporation, immediately downstream from Portland Terminal

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Four, and the lowlands that are now filled for Rivergate Industrial District. The area within Sauvie Island is divided roughly in half by two diking districts. The northern half, which contains the Columbia Diking District, was flooded. The floodwaters caused damage to farmland, residences, and farm structures. The southern half, protected by the Sauvie Island Drainage District, was nearly flooded. Sandbags were added to approximately 4 miles of levee crest to reinforce the levees, which were seeping heavily (Reference 8).

The December 1964 winter flood resulted from intense rainfall augmented by snowmelt. High concurrent discharges on both Willamette and Columbia Rivers resulted in unusually high flood stages in Multnomah County. Along Willamette River in the southern portion of the county, damage to residences was heavy. However, downstream of Portland, flood heights were less than in 1948, and damage to property fronting on Columbia and Willamette Rivers and Multnomah Channel was limited to houseboats, boat moorages, and a lumber mill. A Hayden Island mobile home court was partially inundated, and adjacent areas of the island were flooded. Without reservoir control, the 1964 flood would have exceeded the 1894 and 1948 floods at the Morrison Street Bridge gage.

The Sandy River watershed has experienced many flood events. Recent significant floods occurred in December 1964, January 1956, and January 1972. These floods had recurrence intervals of 300, 10, and 30 years, respectively (Reference 9). Flows of 61,400, 23,900, and 36,200 cfs, respectively, were recorded at the U.S. Geological Survey (USGS) Marmot gage. This gage was established in 1911, and measures data from a drainage area of 282 square miles (Reference 10). Because the flood plain is only lightly developed, damage in the unincorporated portions of the county was relatively minor. Most of the damage consisted of severe bank erosion, as most of the homes along the stream were above the flood levels. Downstream of the Troutdale corporate limits, Sandy River flood elevations are controlled by Columbia River stages.

The Johnson Creek flood season extends from October through March. Records show that Johnson Creek has exceeded major flood stage 10 times since 1941 at the Sycamore gage. Recent floods include January 1972 and December 1977, which had peak discharges of 2,190 and 2,230 cfs, respectively, and average recurrence intervals of approximately 10 years (References 11 and 12). The December 1964 flood had a peak discharge of 2,620 cfs and an average recurrence interval of approximately 15 years (Reference 13). Floods having average recurrence intervals larger than 10 years inundate the low-lying area between 100th Avenue and 122nd Avenue as far north as Harold Street. During a 100-year flood, this inundated area is expected to extend as far east as 140th Avenue and Holgate Street.

Past flood damage along the remaining streams studied is not well documented. Damage has been relatively low, however, because these streams are small and located in partially developed areas.

Figures 2 through 5 are photographs of flooding in Multnomah County.

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Figure 2. January 1948 Johnson Creek Flood, Looking Northwest Toward Intersection of Portland Traction Railroad and Foster Road

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Figure 3. June 1948 Columbia River Flood, Looking North Toward Sauvie Island

Figure 4. December 1964 Flood, Looking North Toward Sauvie Island and the Multnomah Channel Exit From Willamette River

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Figure 5. December 1964 Flood, Looking Southwest at Hayden Island and Interstate Highway 5 Bridge

2.4 Flood Protection Measures

A significant flood elevation reduction on Columbia and Willamette Rivers, and Multnomah Channel, has been achieved through the use of flood-control storage reservoirs. There are 22 major reservoirs in the Columbia River Basin upstream of Multnomah County, with a total flood-control storage volume of approximately 40 million acre-feet (Reference 14). There are 11 major flood-control reservoirs in the Willamette River Basin, with approximately 1.7 million acre-feet of flood storage. The stage-reduction effect of the Columbia and Willamette River flood-control storage reservoirs is shown in Table 3 (Reference 6).

The drainage districts along Columbia River in the unincorporated portions of Multnomah County have levees of varying flood-protection capabilities. Thus, safe-water levels have been established by the COE (Reference 15). The safe-water level is the highest flood elevation, considering surveillance and minor remedial work, for which reasonable assurance can be given that a levee system will not fail. The criteria used to evaluate protection against the 100-year flood are 1) adequate design, including freeboard, 2) structural stability, and 3) proper operation and maintenance. Levees that do not protect against the 100-year flood are not considered in the hydraulic analysis of the 100-year flood plain. Columbia Drainage District levees on the northern end of Sauvie Island would be overtopped by a 100-year flood, whereas Sauvie Island Drainage District, Multnomah Drainage District No. 1, and Sandy Drainage District, with proper surveillance and maintenance, are expected to withstand the 500-year flood event. Although the perimeter levee of a particular drainage district may be capable of withstanding large floods, major rainstorms could cause extensive interior ponding in low areas if runoff exceeds the capacity of the dewatering-drainage pumps.

There are no flood-control structures on Sandy River, Johnson Creek, Fairview Creek, or Unnamed Tributary to Rock Creek.

Nonstructural measures are also being used to aid in the prevention of future flood damage. Multnomah County is enforcing paragraph 1910.3 of the regulations for the NFIP. The regulations require that the county use existing flood plain information to determine whether new developments are reasonably safe from flooding. The county requires new developments to have first-floor elevations at or above 100-year flood levels and discourages development within the floodway. A county comprehensive plan was adopted in June 1979. The plan shows flood hazard areas and references existing flood plain information.

Elected officials of the tri-county Metropolitan Service District, formed in May 1978, have established a Johnson Creek Task Force representing the six counties and communities within that drainage basin. The task force has proposed storm water runoff management

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Table 3. Regulatory Effect of Flood-Control Reservoirs

Location	Flood Crest Elevations (Feet) June 1894	June 1948	June 1956	Dec. 1964
Vancouver Gage, Columbia River				
Observed	36.2	32.8	29.4	29.5
Unregulated	36.2	32.8	31.8	34.3
Regulated[1]	24.1	23.3	18.8	28.5
Portland Gage, Willamette River				
Observed	34.6	31.5	28.0	31.4
Unregulated	34.6	31.6	30.3	36.0
Regulated[1]	22.5	21.7	17.2	30.5
Days Duration Above Flood Stage[2]				
Bankfull	74	51	70	9
Major Flood	38	26	12	2

[1] Based on present level of irrigation and reservoir development

[2] Flood or bankfull stage for Columbia River is 17.8 feet at the Vancouver gage. A flood of 27.8 feet or higher results in extensive damage and is considered a major flood.

16

guidelines for adoption by the six political bodies. These guidelines apply to new development and are intended to control the rate of storm water runoff, thereby stemming the upward trend in flood damage. The task force is also considering a detailed drainage management plan, channel clearing and cleaning, and institution of an annual channel maintenance program.

The City of Portland completed a rechannelization and channel modification along Johnson Creek between River Miles 6.8 and 7.2 in January 1983. This project has reduced the 100-year flood elevations through this reach.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the county, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the county at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the county.

The stage-discharge relationship for Columbia River and Multnomah Channel near Multnomah County is influenced by ocean tides and by stages on Willamette River. Similarly, the stage-discharge relationship of Willamette River in the study area is influenced by stages on Columbia River. Thus, flood frequencies on both rivers and Multnomah Channel are more reliably determined for stages than for discharges. Combined stage-frequency curves were developed for seven locations on Willamette River. Those locations include USGS gage No. 14144700 on Columbia River at Vancouver, Washington

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(Reference 16), and USGS gage No. 1421172 on Willamette River at the Morrison Street Bridge (Reference 17). Both gages were established in 1876. These curves were based on the statistical combination of stage-frequency curves for fall-winter floods and spring-summer floods.

Multnomah Channel discharges were estimated using the COE HEC-2 step-backwater computer program (Reference 18). The HEC-2 computer model was calibrated to Columbia and Willamette River flood profiles, and Multnomah Channel discharges were derived by a trial-and-correction process.

The hydrologic analysis for Sandy River was performed by the SCS, Oregon State Office. The analysis used the standard log-Pearson Type III methods as outlined by the U.S. Water Resources Council (Reference 19). It was based on records for the Sandy River gage below Bull River, Oregon. That gage has a drainage area of 440 square miles and was in existence from 1929 to 1966. Flows computed at the gage were adjusted to compensate for the increase in drainage area downstream of the gage to the study area.

Stream gage records for Johnson Creek were statistically analyzed using the standard log-Pearson Type III distribution. A discharge-frequency curve (Reference 13) for the Johnson Creek stream gage at Sycamore was developed using records from 1941 to 1972. Peak discharges were adjusted downstream of the Sycamore gage to account for overbank storage in a large depression that extends from Interstate Highway 205 east to 140th Avenue and from Johnson Creek north to Holgate Street. The 10- and 50-year discharges were reduced to compensate for flood storage available in that depression. The depression was considered to fill before peak 100- and 500-year floodflows occur.

Discharges for Fairview Creek and Unnamed Tributary to Rock Creek were determined by correlations with available stream discharge-frequency relationships for similar watersheds. The discharges for Fairview Creek were correlated with Beaver Creek and Johnson Creek based on drainage area and slope on the discharge-frequency curves. The Unnamed Tributary to Rock Creek 100-year discharges were computed using a COE standardized procedure for ungaged streams (Reference 20). The discharge-frequency curve slope was correlated with an existing curve for Burnt Bridge Creek (Reference 21).

Peak discharge-drainage area relationships for Sandy River, Johnson Creek, Fairview Creek, and Unnamed Tributary to Rock Creek are shown in Table 4.

The rate and volume of runoff for the 100-year flood within Multnomah County Drainage District No. 1 were determined using the Environmental Protection Agency Stormwater Management Model (Reference 22). The model calculates the rate of runoff at specific time intervals

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Table 4. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Sandy River					
At Mouth	502	48,000	72,000	82,800	129,200
At Dabney Park	483	46,500	69,700	80,100	125,000
Johnson Creek					
At 82nd Avenue	46	2,450	4,050	5,400	7,700
At USGS Gage	28	2,350	3,700	4,350	6,200
At Southeast 174th Avenue	21	1,840	2,870	3,400	4,930
At Southeast 252nd Avenue	7	870	1,370	1,630	2,350
Fairview Creek					
At Southeast Burnside Road	1.9	85	135	160	230
Unnamed Tributary to Rock Creek					
At Kaiser Road	3.2	160	240	260	340

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throughout the storm based on characteristics of rainfall and the physical characteristics of the drainage basin. The computed runoff draining into Columbia Slough was then balanced against the ability of the drainage district pumps to discharge water from the slough. The volume of runoff draining to the slough that exceeded district pumping capabilities was calculated at specific time intervals throughout the storm. The peak water-surface elevation for the 100-year storm was then determined using the volume of storage at various elevations in the slough (Reference 1).

Discharges used for approximate-study stream lengths were derived by correlations with similar drainage basins and based on a comparison of drainage areas.

Elevations for floods of the selected recurrence intervals on Columbia River, Willamette River, and Multnomah Channel are shown in Table 5.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

Water-surface elevations were computed through the use of the COE HEC-2 step-backwater program (Reference 18).

Columbia River flood profiles for specific recurrence intervals were plotted directly from the combined stage-frequency curves described in Section 3.1. The HEC-2 computer program was calibrated to the plotted 100-year profile and used for the Columbia River floodway determination. Discharges used in the floodway computations were correlated, based on data at USGS gage No. 14105700 (established in 1857) at The Dalles, Oregon (Reference 23), to yield water-surface elevations similar to the combined stage-frequency curves.

Willamette River flood profiles are referenced to combined frequency computations for the Morrison Street Bridge gage. A HEC-2 computer model was used to estimate flood elevations upstream and downstream of the gage. Discharges used in the HEC-2 model were correlated, based on data at USGS gage No. 1419100 (established in 1892) at Salem, Oregon (Reference 23), to yield water-surface elevations similar to the combined stage-frequency curves.

The HEC-2 program was used to prepare Multnomah Channel flood profiles that connect corresponding Columbia and Willamette River combined frequency flood profiles downstream and upstream of the study reach.

Flood profiles for Sandy River were computed by the SCS. The analysis used the SCS computer model to compute flood stages at each cross section. The profiles were prepared by SCS for a 1977 report (Reference 24).

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Table 5. Summary of Elevations

Flooding Source and Location	Drainage Area (Square Miles)	Elevation (Feet) 10-Year	50-Year	100-Year	500-Year
Columbia River					
At Vancouver, Washington (River Mile 106.5)	241,000	22.3	26.4	28.1	31.7
Willamette River					
At Morrison Street Bridge (River Mile 12.8)	11,200	22.0	26.7	28.8	33.7
Multnomah Channel					
At Sauvie Island Bridge	--[1]	21.7	25.8	27.4	31.5

[1]Not Applicable

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Johnson Creek flood profiles were computed using the HEC-2 step-backwater computer program, with the exception of the stream length between Telford Road and U.S. Highway 26. There are three complex bridges in that area that could not be modeled reliably by computer; thus, manual computations were made.

Fairview Creek flood profiles were also computed using the HEC-2 step-backwater program with the exception of the area near the Stark Street culvert. Manual calculations were used to determine the hydraulic losses through this culvert.

Due to limitations of map scale and the use of established river miles, stream distances as depicted on the flood profiles may not always match those depicted on the maps.

The HEC-2 analysis of Unnamed Tributary to Rock Creek had to compensate for sheet flow losses. During floods, the stream overtops its north bank and flows westerly across the county boundary. Flows were reduced in the computer model to account for these losses.

Columbia and Willamette River cross sections were based on COE condition surveys, dated 1974 and 1976, and topographic maps (References 25 through 30). Multnomah Channel cross sections were measured by hydrographic survey methods. Cross sections for Sandy River, Johnson Creek, Fairview Creek, and Unnamed Tributary to Rock Creek were field measured. Overbank topography for Multnomah Channel was defined by USGS topographic maps (Reference 26). Cross sections on Johnson and Fairview Creeks were supplemented with information from topographic maps (Reference 27). Bridge drawings for structures on Columbia and Willamette Rivers were provided by government agencies and private industry. Bridge information for structures on Sandy River, Johnson Creek, and Fairview Creek was obtained by field measurement.

Roughness values (Manning's "n") used in detailed hydraulic computations were chosen by engineering judgment and based on field observations of the streams and flood plain areas. Ranges of roughness values used for the main channel were: Columbia River, from 0.025 to 0.038; Willamette River, from 0.030 to 0.050; Multnomah Channel, 0.030; Johnson Creek, from 0.030 to 0.045; Sandy River, from 0.025 to 0.050; Fairview Creek, from 0.040 to 0.042; and Unnamed Tributary to Rock Creek, from 0.015 to 0.080. Overbank flood plain roughness values for the detailed study segments varied from 0.050 to 0.100. The acceptability of all assumed hydraulic factors, cross sections, and hydraulic structure data was checked by computations that duplicated historical flood profiles (Reference 31).

The starting water-surface elevations for Columbia River flood profiles were based on the appropriate combined stage-frequency curve, while Willamette River and Multnomah Channel starting elevations were on coinciding Columbia River flood elevations.

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Johnson Creek starting elevations were obtained from the Flood Insurance Study for the City of Portland (Reference 32). Previous flood elevations, channel slopes, and bank elevations were considered when the starting water-surface elevations were determined for Sandy River, Fairview Creek, and Unnamed Tributary to Rock Creek.

Water-surface elevations within Multnomah County Drainage District No. 1 are based on a July 1984 hydrology study for the district (Reference 1). As a result of this study, the 100-year water-surface elevation within the district was reduced from 17 feet to 14 feet.

The approximate analysis on Columbia River upstream of Sandy River was based on existing 100-year profiles (Reference 33) and existing topographic maps (Reference 25). Sandy River approximate analysis included field investigations to recover the 1964 high-water marks and normal-depth calculations to define the flood plain, using available topographic information (References 26 and 34). Kelley, Beaver, and Fairview Creek approximate analyses were completed based on existing topographic information (Reference 27) and normal-depth calculations.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study produces maps designed to assist communities in developing flood plain management measures.

4.1 Flood Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for flood plain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate

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additional areas of flood risk in the community. For each stream studied in detail, the 100- and 500-year flood plain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at scales of 1:1,200 and 1:2,400, with a contour interval of 2 feet; and 1:24,000, with contour intervals of 10 and 20 feet (References 25 through 30).

The 100- and 500-year flood plain boundaries are shown on the Flood Boundary and Floodway Map (Exhibit 2). In cases where the 100- and 500-year flood plain boundaries are close together, only the 100-year flood plain boundary has been shown. Small areas within the flood plain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, the boundaries of the 100-year flood were delineated on the aforementioned topographic maps in conjunction with previously estimated elevations.

Boundaries for the shallow flooding areas were delineated using topographic maps at a scale of 1:2,400, with a contour interval of 2 feet (Reference 27), in conjunction with the previously estimated elevations.

For the streams studied by approximate methods, only the 100-year flood plain boundary is shown.

4.2 Floodways

Encroachment on flood plains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood plain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed on the basis of equal-conveyance reduction from each side of the flood plain. The results of these computations are tabulated at selected cross

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sections for each stream segment for which a floodway is computed (Table 6).

Portions of the floodways of Columbia River, Willamette River, and Johnson Creek are outside of the unincorporated areas of Multnomah County.

No floodway is delineated for Sandy River downstream of the Union Pacific Railroad bridge due to the low development potential of that area. No floodway is delineated upstream of Clark Road on Johnson Creek due to the steep stream gradient in that area. Both of these decisions were agreed upon by the study contractor and FEMA.

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were computed at cross sections. Between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year flood plain boundaries are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and 100-year flood plain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 6.

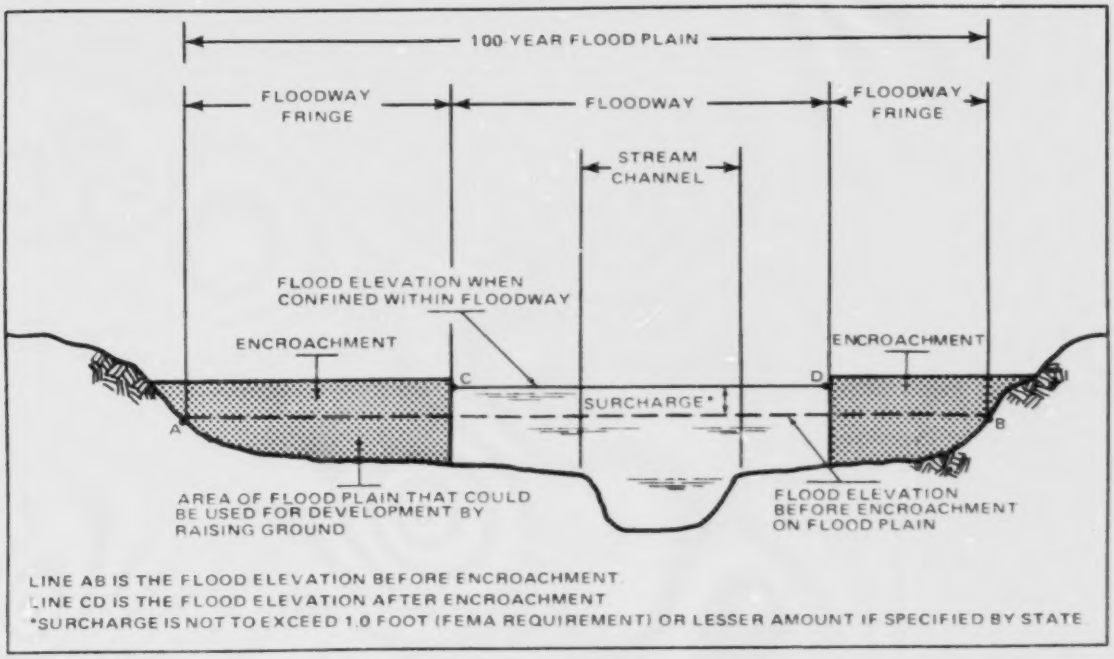
100-YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE

Figure 6. Floodway Schematic

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY[3]	WITHOUT FLOODWAY[4]	WITH FLOODWAY[4]	INCREASE
					(FEET NGVD)			
Columbia River								
A	96.49	3550/1450	165,476	4.6	25.5	25.6	26.4	0.8
B	98.43	3950/1130	159,986	4.8	26.0	26.2	27.0	0.8
C	99.28	2959/1100	140,334	5.4	26.3	26.5	27.2	0.7
D	100.43	3521/1435	168,626	4.5	26.5	27.0	27.7	0.7
E	101.20	3363/1150	195,911	3.9	26.7	27.3	27.9	0.6
F	102.18	3233/2360	222,371	2.5	26.9	27.6	28.2	0.6
G	104.43	3630/2290	184,160	3.1	27.5	27.8	28.5	0.7
H	105.63	3423/1763	164,083	3.4	27.9	28.0	29.0	1.0
I	106.42	3285/1575	147,137	3.8	28.1	28.1	29.1	1.0
J	107.39	4594/3084	189,801	3.0	28.4	28.4	29.4	1.0
K	109.49	4960/2720	205,123	2.8	28.8	28.6	29.6	1.0
L	110.17	4000/2970	161,601	3.5	28.9	28.7	29.6	0.9
M	111.15	4619/3800	185,625	3.0	29.2	28.9	29.8	0.9
N	112.93	7375/6625	192,568	2.9	29.5	29.2	30.1	0.9
O	115.02	4312/3262	161,857	3.5	30.1	29.6	30.5	0.9
P	116.10	4773/3310	178,406	3.2	30.4	29.9	30.8	0.9
Q	118.06	6731/2600	210,779	2.7	30.9	30.3	31.1	0.8
R	119.88	2280/970	127,035	4.4	31.3	30.6	31.4	0.8
S	121.37	4250/3270	157,277	3.6	31.6	31.0	31.8	0.8
T	122.86	5500/3700	189,310	2.9	31.8	31.4	32.2	0.8
U	123.42	5700/3610	197,499	2.8	32.0	31.5	32.4	0.9
V	123.98	5800/3290	206,916	2.7	32.1	31.5	32.4	0.9
W	125.54	6950/2220	198,505	2.8	32.3	31.8	32.7	0.9
X	126.58	5900/600	173,646	3.2	32.5	31.9	32.8	0.9

[1]Miles Above Mouth [2]Width/Width Within Study Area [3]Elevations Based on Combined Stage-Frequency Curve
[4]Elevations Based on HEC-2 Model Calibrated to Approximate 100-Year Combined Stage-Frequency Curve

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH COUNTY, OR
(UNINCORPORATED AREAS)

FLOODWAY DATA

COLUMBIA RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Willamette River								
A	0.38	1600/1260[2]	85,130	3.1	27.3	25.9[3]	26.7[3]	0.8
B	1.52	1700/1600[2]	113,090	2.3	27.4	26.0[3]	26.8[3]	0.8
C	2.40	2300	142,790	1.8	27.4	26.1[3]	26.9[3]	0.8
D	3.03	2073/1853[2]	110,545	2.4	27.4	26.1[3]	26.9[3]	0.8
F	17.83	985/570[2]	63,627	5.9	31.7	31.7	32.6	0.9
G	18.31	815/640[2]	51,102	7.3	32.0	32.0	32.9	0.9
H	18.63	1325/730[2]	85,861	4.4	32.8	32.8	33.6	0.8
I	19.10	1530/300[2]	63,914	5.9	32.8	32.8	33.6	0.8

[1]Miles Above Mouth [2]Width/Width Within Study Area [3]Elevation Computed Without Consideration of Influence From Columbia River

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH COUNTY, OR
(UNINCORPORATED AREAS)

FLOODWAY DATA

WILLAMETTE RIVER

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
						(FEET NGVD)		
Multnomah Channel								
A	12.68	800	28,977	3.9	25.4	23.4[2]	24.3[2]	0.9
B	14.79	760	28,278	4.0	26.2	24.0[2]	24.9[2]	0.9
C	17.03	800	30,177	3.7	26.6	24.6[2]	25.4[2]	0.8
D	19.08	780	30,687	3.6	27.1	24.9[2]	25.8[2]	0.9
E	20.55	800	40,034	2.8	27.3	25.1[2]	26.1[2]	1.0
F	21.21	800	38,085	2.9	27.4	25.2[2]	26.2[2]	1.0
Sandy River								
A	4.35	365	8,735	9.22	42.6	42.6	43.6	1.0
B	4.55	644	11,994	6.70	44.3	44.3	45.3	1.0
C	4.64	490	10,641	7.56	44.6	44.6	45.6	1.0
D	5.04	467	9,764	8.22	46.6	46.6	47.6	1.0
E	5.42	281	6,892	11.65	47.9	47.9	48.9	1.0
F	5.76	226	5,908	13.57	49.6	49.6	50.6	1.0
G	5.79	253	6,452	12.43	50.5	50.5	51.5	1.0
H	6.17	786	17,309	4.63	53.1	53.1	54.1	1.0

[1]Miles Above Mouth [2]Elevations Computed Without Consideration of Influence From Columbia and Willamette Rivers

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH COUNTY, OR
(UNINCORPORATED AREAS)

FLOODWAY DATA

MULTNOMAH CHANNEL-SANDY RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Johnson Creek								
A	5.644	123	652	8.3	193.2	193.2	193.2	0.0
B	5.170	206	1,213	4.1	197.0	197.0	197.0	0.0
C	6.011	380	2,163	2.3	197.9	197.9	198.2	0.3
D	6.083	251	1,107	4.5	197.9	197.9	198.2	0.3
E	6.197	285/75[2]	810	6.2	198.0	198.0	198.6	0.6
G	7.269	800[3]	2,082	2.4	208.6	208.6	209.5	0.9
H	7.350	1000[3]	2,288	2.2	208.9	208.9	209.9	1.0
I	7.538	1069[3]	2,642	1.9	209.4	209.4	210.3	0.9
J	7.646	1070[3]	1,738	2.9	211.7	211.7	212.4	0.7
K	7.947	900[3]	2,185	2.2	213.1	213.1	231.7	0.6
L	8.032	625[3]	1,562	3.0	213.6	213.6	214.2	0.6
M	8.222	500[3]	1,993	2.5	214.2	214.2	215.0	0.8
N	8.968	60[3]	565	7.7	220.5	220.5	221.2	0.7
O	9.623	105[3]	726	6.0	228.9	228.9	229.5	0.6
P	9.763	56/24[2]	496	8.8	231.1	231.1	231.9	0.8
Q	9.973	275/245[2]	1,109	3.9	233.7	233.7	234.3	0.6
R	10.204	52[3]	536	8.1	238.5	238.5	238.9	0.4
S	10.310	85[3]	1,064	4.1	239.7	239.7	240.4	0.7
T	10.545	164[3]	1,654	2.6	242.7	242.7	243.6	0.9
U	11.845	51[3]	737	4.6	248.7	248.7	249.6	0.9
V	11.869	149/129[2]	671	5.1	248.8	248.8	249.7	0.9
W	11.927	100	802	4.2	249.8	249.8	250.8	1.0
X	11.941	101	730	4.7	249.9	249.9	250.7	0.8
Y	12.116	54/35[2]	528	6.4	252.0	252.0	252.5	0.5
Z	12.307	70	612	5.6	254.8	254.8	255.0	0.2

[1]Miles Above Mouth [2]Width/Width Within Study Area [3]Floodway Located Entirely Outside Study Area

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH COUNTY, OR
(UNINCORPORATED AREAS)

FLOODWAY DATA

JOHNSON CREEK

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Johnson Creek (Cont'd)								
AA	12.473	41	499	6.8	256.0	256.0	257.0	1.0
AB	12.617	55	478	7.1	257.2	257.2	258.1	0.9
AC	18.228	75	377	6.6	356.3	356.3	357.2	0.9
AD	18.335	44	269	9.3	359.6	359.6	360.6	1.0
AE	18.583	123	699	3.6	372.8	372.8	373.8	1.0
AF	18.719	60	329	7.6	374.3	374.3	375.2	0.9
AG	18.919	80	340	7.4	382.2	382.2	383.0	0.8
AH	19.053	87	440	5.7	386.9	386.9	387.8	0.9
AI	19.242	144	524	4.5	394.1	394.1	394.9	0.8
AJ	19.427	62	247	4.0	400.7	400.7	401.7	1.0
AK	19.432	135	733	1.4	401.1	401.1	402.0	0.9
AL	19.444	170	1,067	0.9	402.4	402.4	403.4	1.0
AM	19.600	31	138	7.2	405.4	405.4	406.3	0.9
AN	19.856	73	413	2.4	415.0	415.0	415.8	0.8
AO	20.515	26	93	10.6	435.7	435.7	436.4	0.7
AP	20.650	200	451	2.2	442.5	442.5	443.5	1.0
AQ	20.670	258	1,669	0.6	446.9	446.9	447.7	0.8
AR	20.770	57	182	5.5	447.9	447.9	448.9	1.0
AS	20.951	39	161	6.1	455.5	455.5	456.2	0.7
AT	21.153	73	233	4.3	460.5	460.5	461.1	0.6
AU	21.389	29	124	8.0	468.8	468.8	469.3	0.5
AV	21.472	77	309	3.2	471.0	471.0	471.7	0.7
AW	21.545	40	151	6.6	472.6	472.6	473.3	0.7
AX	21.668	30	143	6.9	477.9	477.9	478.4	0.5
AY	21.677	30	218	4.5	480.5	480.5	481.1	0.6
AZ	21.777	33	130	7.6	482.2	482.2	483.1	0.9

[1]Miles Above Mouth

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH COUNTY, OR
(UNINCORPORATED AREAS)

FLOODWAY DATA

JOHNSON CREEK

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Johnson Creek (Cont'd)								
BA	22.000	61	215	4.6	491.3	491.3	492.1	0.8
BB	22.144	93	265	2.2	492.9	492.9	493.9	1.0
BC	22.211	29/15[2]	90	6.4	494.3	494.3	494.9	0.6
Fairview Creek								
A	3.451	20[3]	44	5.0	234.0	234.0	234.8	0.8
B	3.585	16[3]	50	4.2	238.3	238.3	238.9	0.6
C	3.602	50	156	1.2	243.5	243.5	244.5	1.0
D	3.649	12	41	4.7	244.0	244.0	244.9	0.9
E	3.753	14	56	3.5	246.3	246.3	246.8	0.5
F	3.829	19	36	5.3	248.5	248.5	248.5	0.0
G	3.933	15	42	3.8	250.6	250.6	250.6	0.0
H	3.954	4	15	10.9	253.7	253.7	253.7	0.0
Unnamed Tributary to Rock Creek								
A	0.74	80/15[4]	122	2.7	201.0	201.0	201.5	0.5
B	0.86	100[3]	173	1.9	204.4	204.4	205.0	0.6
C	0.97	64	106	3.2	207.3	207.3	207.6	0.3
D	1.16	148	263	1.3	210.6	210.6	211.1	0.5
E	1.19	8	32	10.4	211.1	211.1	211.1	0.0
F	1.33	85	173	0.7	215.1	251.1	251.9	0.8

[1]Miles Above Mouth [2]Width/Width Within Study Area [3]Floodway Located Entirely Outside County Limits
[4]Width/Width Within County Limits

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH COUNTY, OR
(UNINCORPORATED AREAS)

FLOODWAY DATA

JOHNSON CREEK-FARIVIEW CREEK-UNNAMED TRIBUTARY TO ROCK CREEK

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5.0 INSURANCE APPLICATION

To establish actuarial insurance rates, data from the engineering study must be transformed into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail affecting the unincorporated areas of Multnomah County, Oregon.

5.1 Reach Determinations

Reaches are defined as sections of flood plain that have relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference may not have a variation greater than that indicated in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of Multnomah County are shown on the Flood Profiles (Exhibit 1) and summarized in Table 7.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is used to establish relationships between depth and frequency of flooding in any reach. This relationship is then used with depth-damage relationships for various classes of structures to establish actuarial insurance rate tables.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations rounded to the nearest one-half foot, multiplied by 10, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10-and 100-year flood water-surface elevations is greater than 10.0 feet, it is rounded to the nearest whole foot.

5.3 Flood Insurance Zones

Flood insurance zones and zone numbers are assigned based on the type of flood hazard and the FHF, respectively. A unique zone number is associated with each possible FHF, and varies from 1 for a FHF of 005 to a maximum of 30 for a FHF of 200 or greater.

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FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Multnomah Drainage District No. 1 Shallow Flooding	0180 0185,0195 0215,0220	N/A	N/A	N/A	N/A	AH	14
Multnomah Channel Reach 1	0030,0040 0045,0130 0135	-5.5	-1.6	4.0	055	A11	Varies - See Map
Sandy River Reach 1	0217,0238	-6.3	-2.0	6.0	065	A13	Varies - See Map
Johnson Creek Reach 1	0379,0381	-4.0	-1.3	1.3	040	A8	Varies - See Map
Reach 2	0381,0382	-1.3	-0.4	0.7	015	A3	Varies - See Map
Reach 3	0381,0382 0401	-2.6	-0.8	2.0	025	A5	Varies - See Map
Reach 4	0406,0407	-1.3	-1.0	0.5	015	A3	Varies - See Map
Reach 5	0407,0409 0428,0429	-1.0	-0.3	0.6	010	A2	Varies - See Map
Fairview Creek Reach 1	0214,0215	-0.8	-0.2	0.4	010	A2	Varies - See Map
Unnamed Tributary to Rock Creek Reach 1	0128,0129	-0.5	-0.1	0.2	005	A1	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

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TABLE 7

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH COUNTY, OR
(UNINCORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

MULTNOMAH DRAINAGE DISTRICT NO. 1-MULTNOMAH CHANNEL-SANDY RIVER-JOHNSON CREEK-FAIRVIEW CREEK-UNNAMED TRIBUTARY TO ROCK CREEK

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Columbia River							
Reach 1	0030,0035						
	0045,0065						
	0155	-5.6	-1.6	3.5	055	A11	Varies - See Map
Reach 2	0065,0155						
	0160,0180						
	0185	-5.8	-1.7	3.6	060	A12	Varies - See Map
Reach 3	0185,0195						
	0205,0215	-5.6	-1.6	3.5	055	A11	Varies - See Map
Reach 4	0205,0210						
	0215,0217						
	0220,0230						
	0240,0245	-5.2	-1.6	3.2	050	A10	Varies - See Map
Willamette River							
Reach 1	0045,0135	-5.9	-1.7	3.9	060	A12	Varies - See Map
Reach 2	0135	-6.8	-2.0	4.6	070	A14	Varies - See Map
Reach 3	0360,0370	-9.4	-3.0	6.5	095	A19	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

TABLE 7

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH COUNTY, OR
(UNINCORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

COLUMBIA RIVER-WILLAMETTE RIVER

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Zone A:	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.
Zone AH:	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; base flood elevations are shown, but no FHFs are determined.
Zones A1, A2, A3, A5, A8, A10-A14, and A19:	Special Flood Hazard Areas inundated by the 100-year flood; with base flood elevations shown, and zones subdivided according to FHFs.
Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood; areas that are protected from the 100- or 500-year floods by dike, levee, or other local water-control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flood hazard; not subdivided.
Zone D:	Areas of undetermined, but possible flood hazard.

The flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the county are summarized in Table 7.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for Multnomah County is, for insurance purposes, the principal product of the Flood Insurance Study. This map contains the official delineation of flood insurance zones and base flood elevations. Base flood elevation lines show the locations of the expected whole-foot water-surface elevation of the base (100-year) flood. The base flood elevations and zone numbers are used by insurance agents, in conjunction with structure elevations and characteristics, to assign actuarial insurance rates to structures and contents insured under the NFIP.

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6.0 OTHER STUDIES

This study is compatible with the Flood Insurance Studies or Flood Hazard Boundary Maps for the Cities of Vancouver, Washington (Reference 35), Fairview (Reference 36), and Gresham (Reference 37). There is a slight discrepancy between some elevations shown for Willamette River for this study and those shown for the Flood Insurance Study for the City of Milwaukie, Oregon (Reference 38). These differences are due to the different analyses performed for these studies. This study is compatible with the Flood Hazard Boundary Maps or Flood Insurance Studies for the Cities of Troutdale (Reference 39), Portland (Reference 32), and Wood Village, Oregon (Reference 40), and the unincorporated areas of Hood River County (Reference 41), Washington County (Reference 42), and Columbia County (Reference 43). The Flood Insurance Study for the unincorporated areas of Clark County, Washington (Reference 44), and the restudy of the unincorporated areas of Clackamas County, Oregon (Reference 45), are in agreement with this study.

There are no flood hazard areas in common between the City of Lake Oswego, Oregon (Reference 46), and this study.

The COE Flood Plain Information report for Milwaukie-Oak Grove-Lake Oswego, which was prepared in 1970 (Reference 47), included Johnson Creek flood profiles. The 100-year flood profile varies within approximately 2 feet of the profile shown in this study. The variation is attributed to slightly different discharge values, changes in stream configuration, development in the flood plain, and more accurate computer modeling techniques.

The COE Columbia and Willamette River flood profiles have been revised for this study by statistically combining spring-summer and fall-winter flood events. The Columbia River spring-summer and fall-winter 100-year flood crests (References 33 and 48), are approximately 1.5 and 2 feet, respectively, below the 100-year combined flood elevation shown at Vancouver Gage in this study. The Willamette River 100-year flood profile (Reference 49) is approximately 2 feet lower than that used in this study near the Portland downstream limit, approximately 1 foot lower near the Morrison Street Bridge, and nearly the same elevation at Sellwood Bridge.

The City of Portland, Multnomah County Drainage District No. 1, and the Port of Portland published Multnomah Drainage District No. 1 Hydrology Study in July 1984 (Reference 1). That report was used to lower the 100-year flood elevations within the district.

7.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, FEMA, Federal Regional Center, 130 228th Street, SW., Bothell, Washington 98011.

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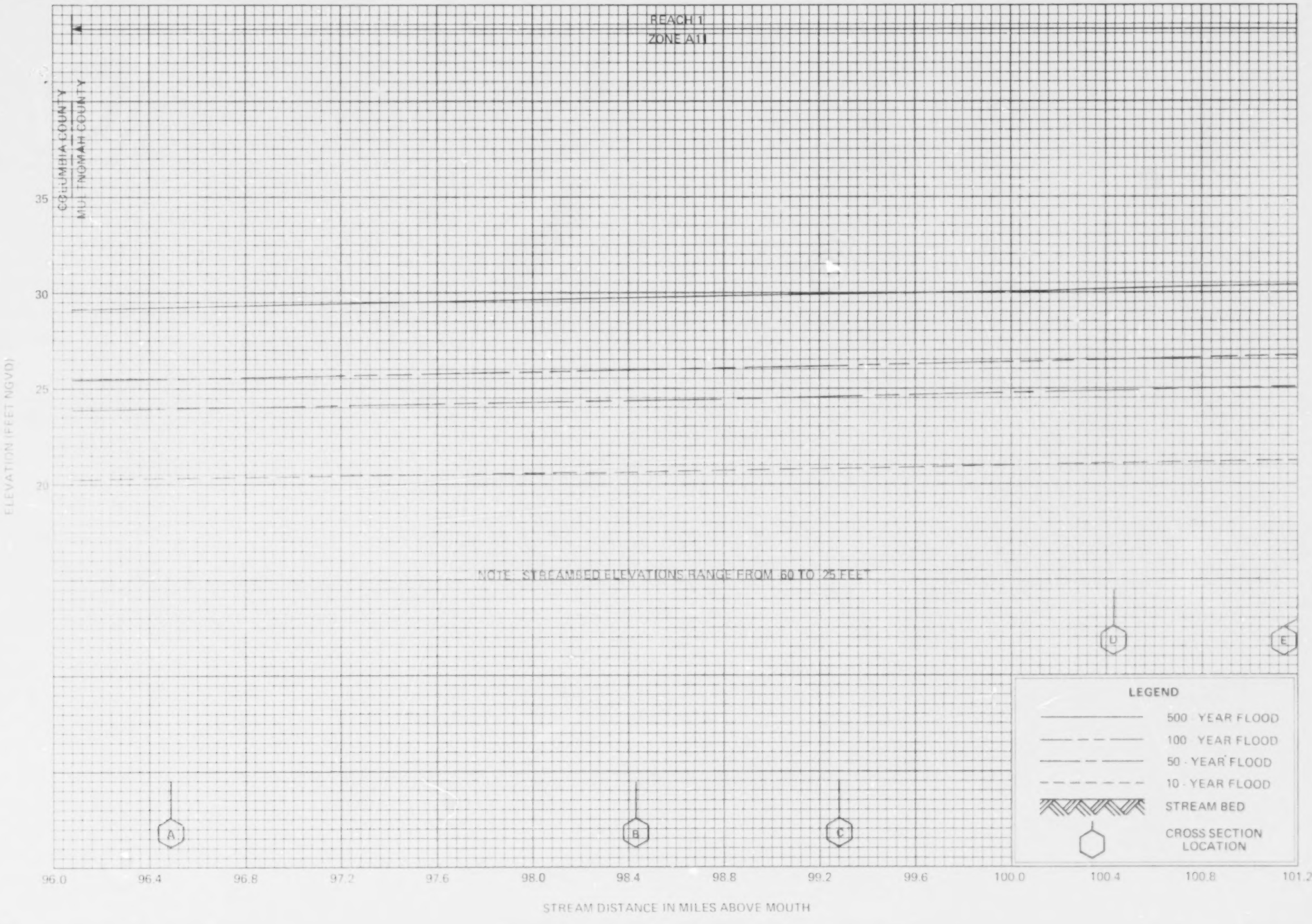

FLOOD PROFILES

COLUMBIA RIVER

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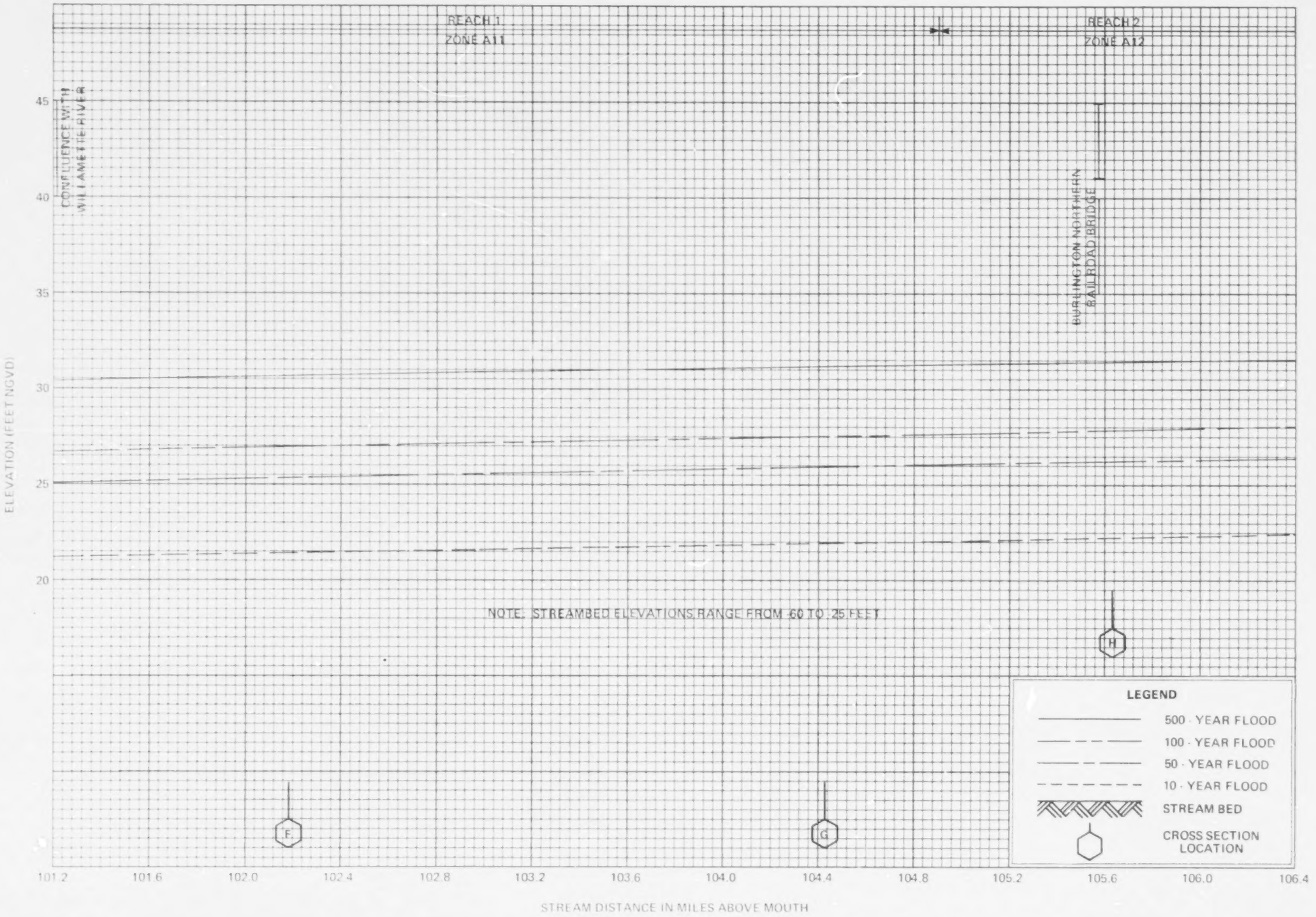

FLOOD PROFILES

COLUMBIA RIVER

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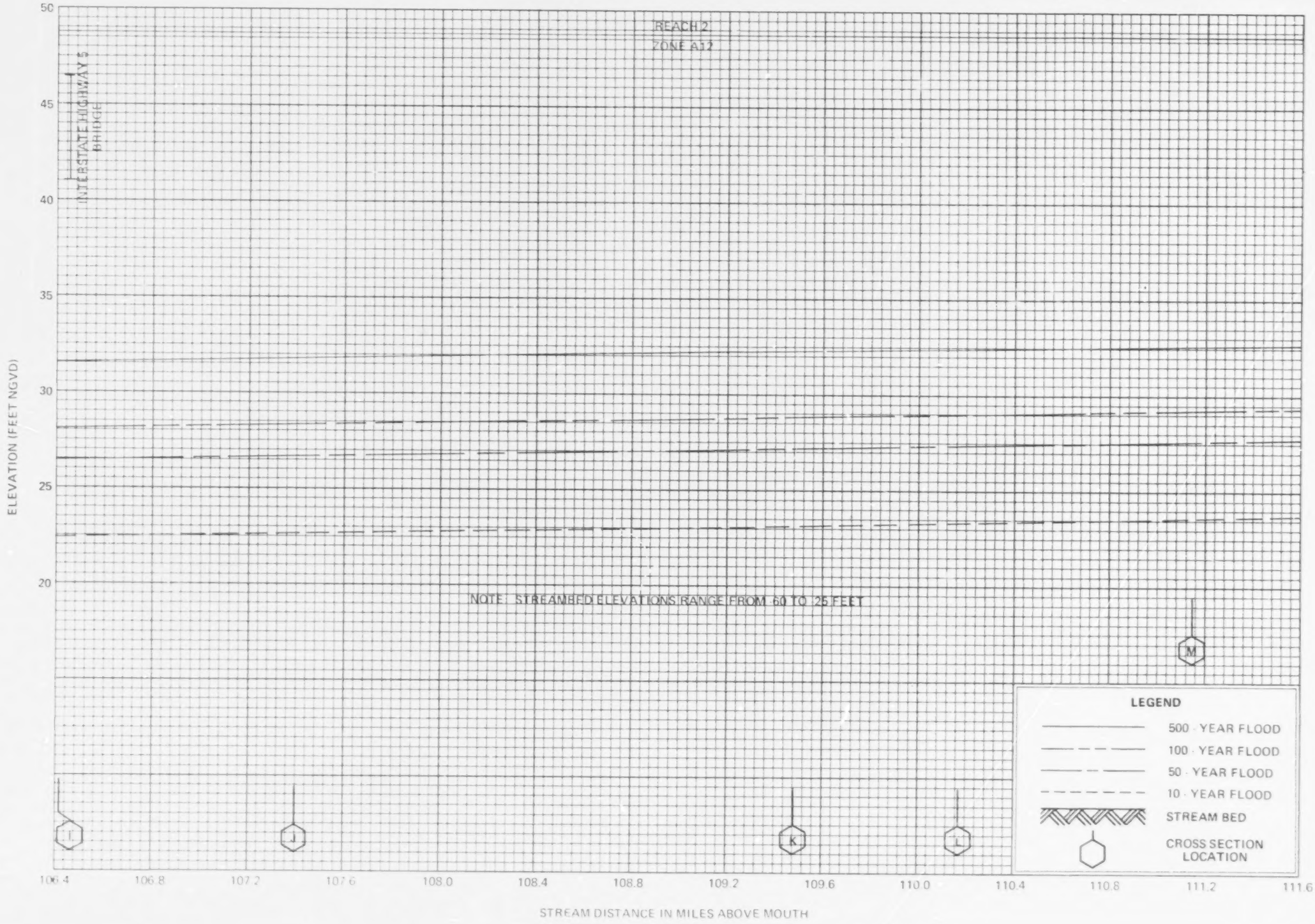

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COLUMBIA RIVER

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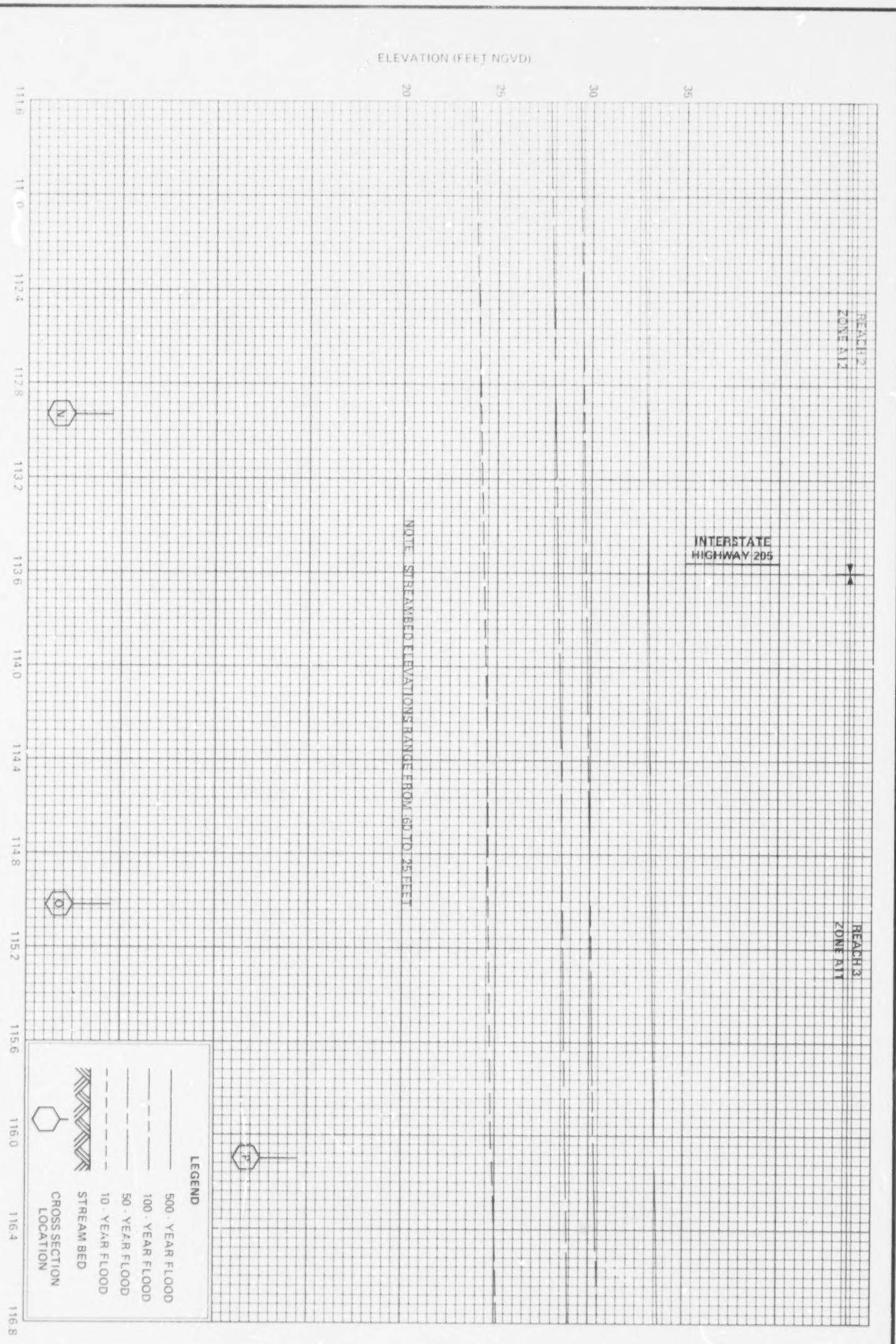

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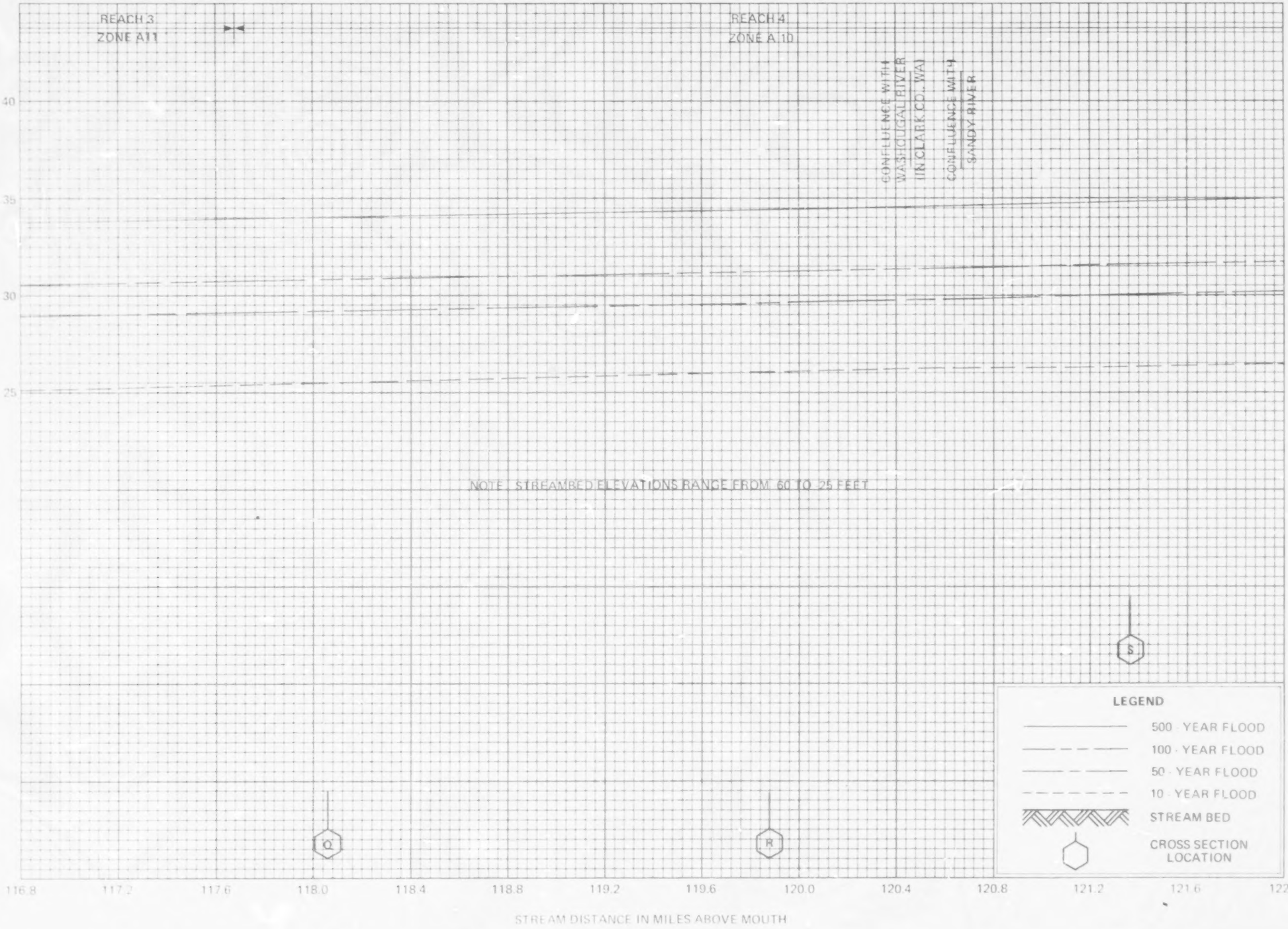

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COLUMBIA RIVER

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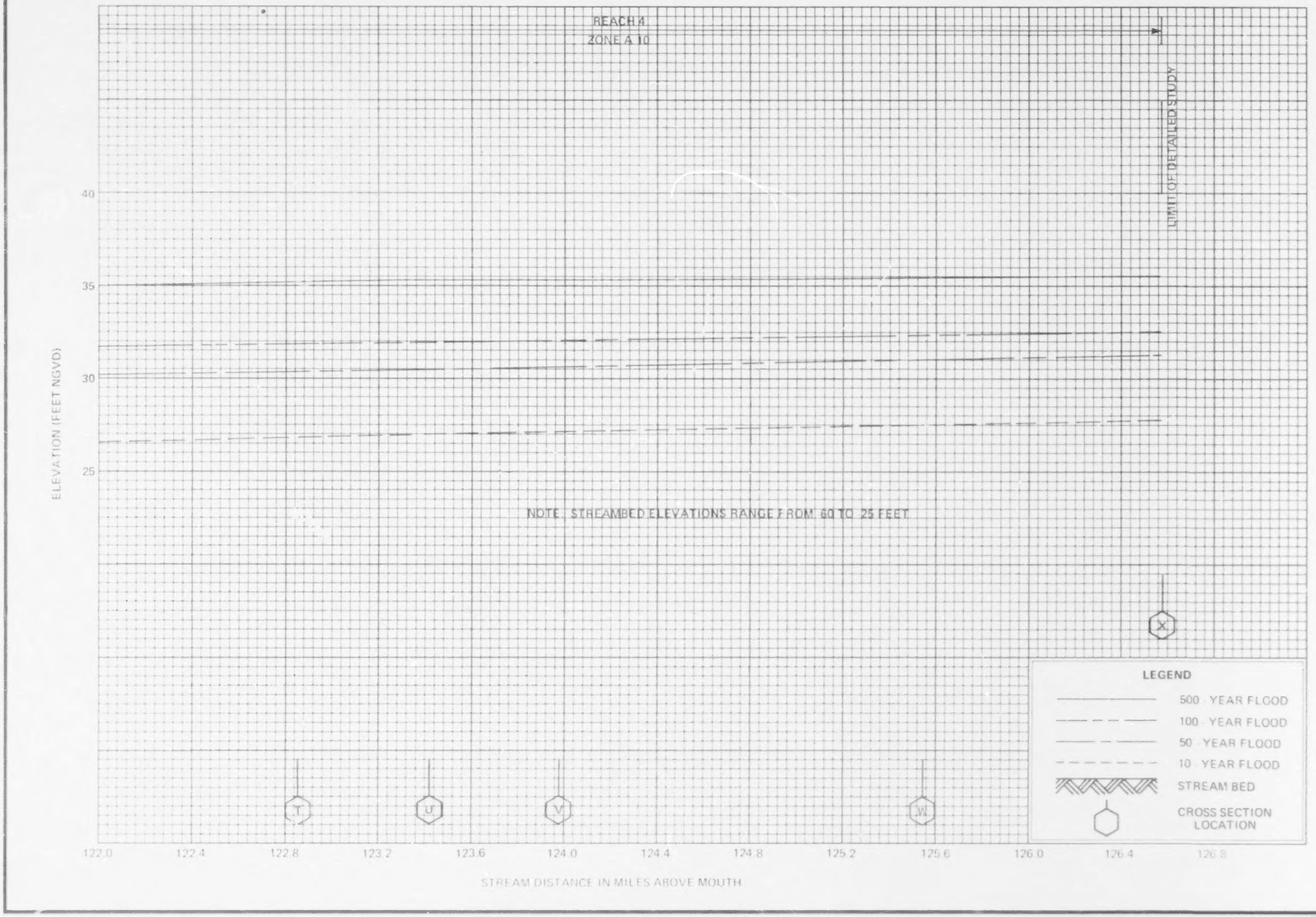

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COLUMBIA RIVER

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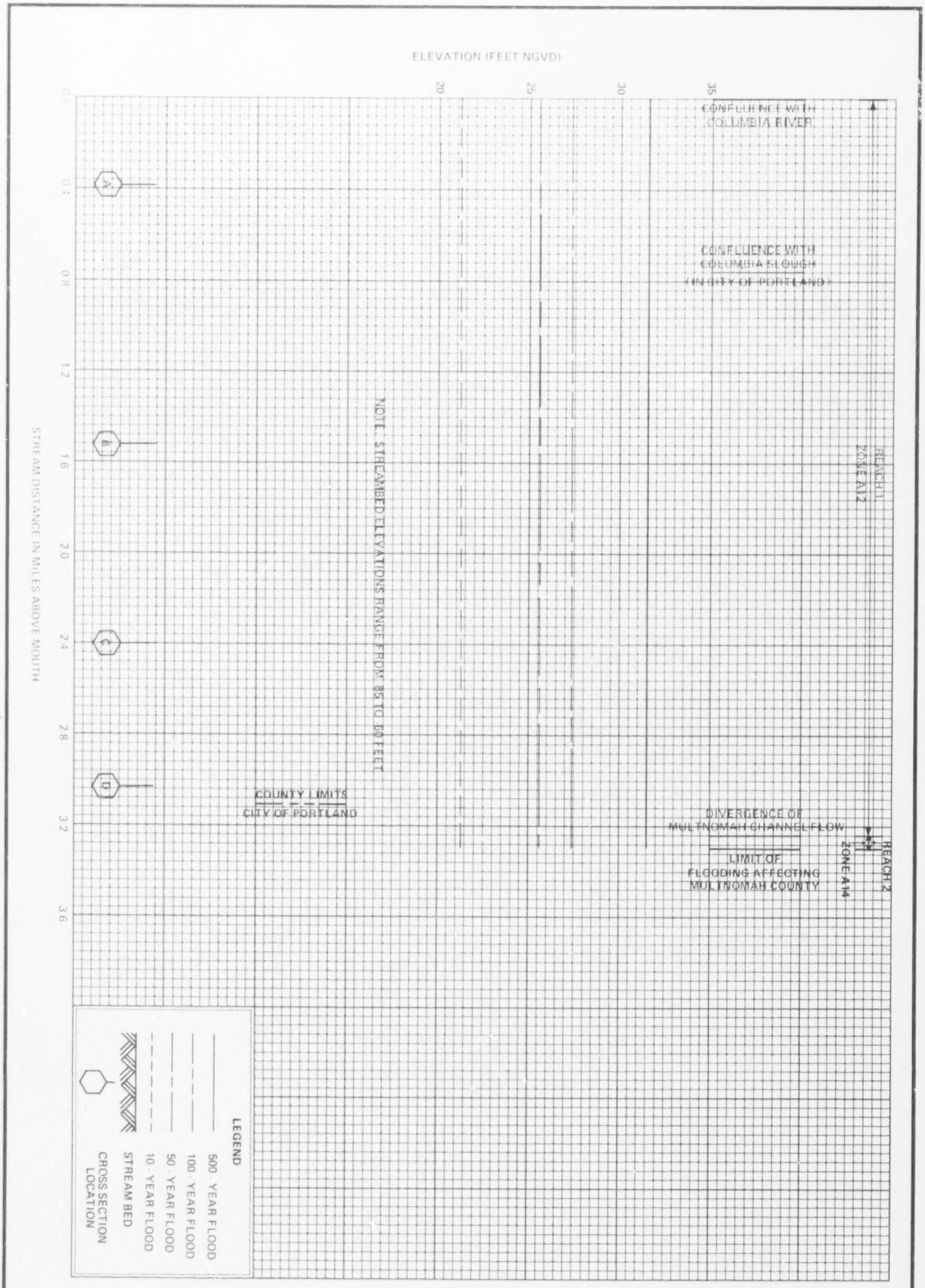

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FLOOD PROFILES

WILLAMETTE RIVER

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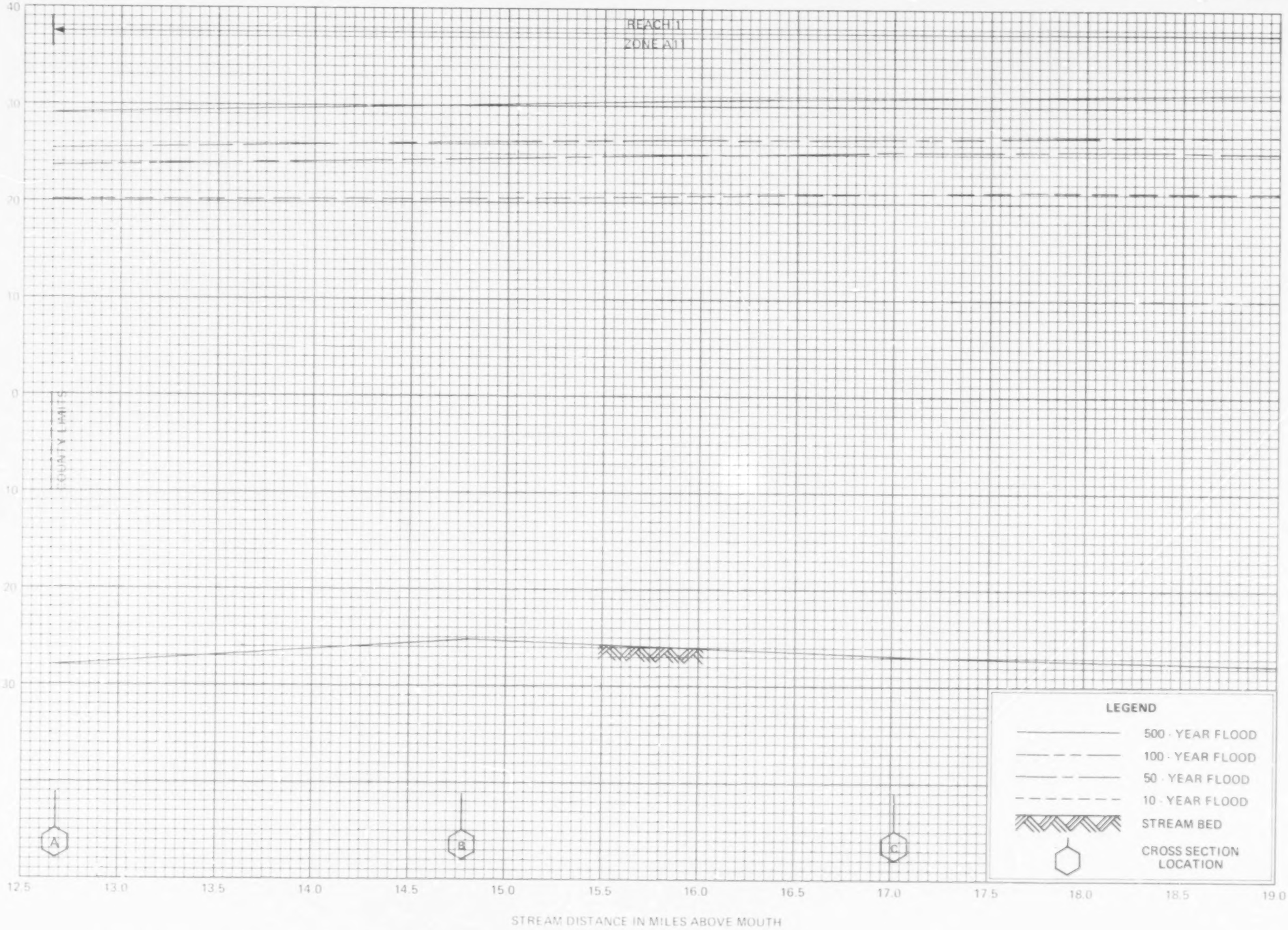

FLOOD PROFILES

MULTNOMAH CHANNEL

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FLOOD PROFILES

MULTNOMAH CHANNEL

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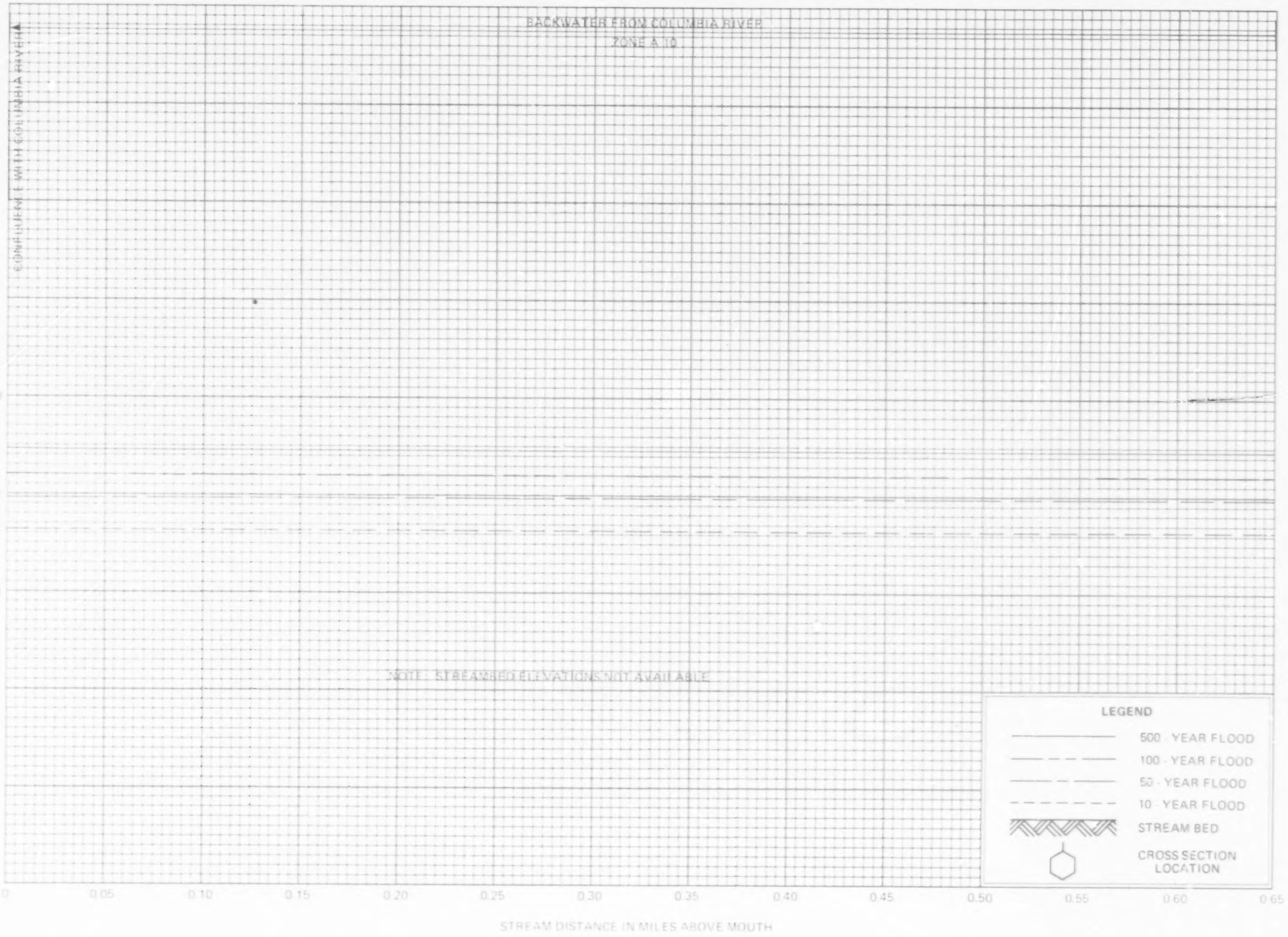

FLOOD PROFILES

SANDY RIVER

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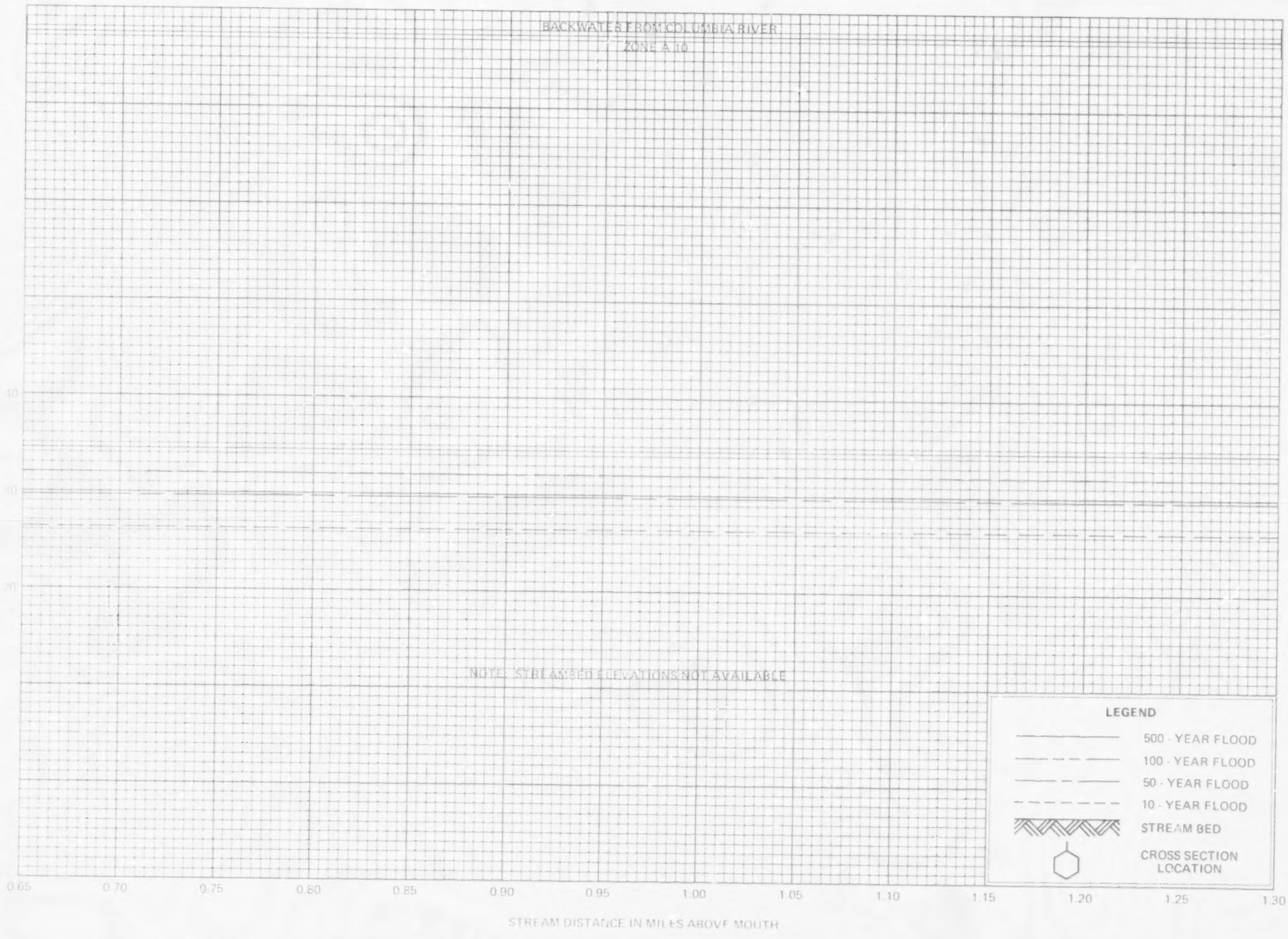

FLOOD PROFILES

SANDY RIVER

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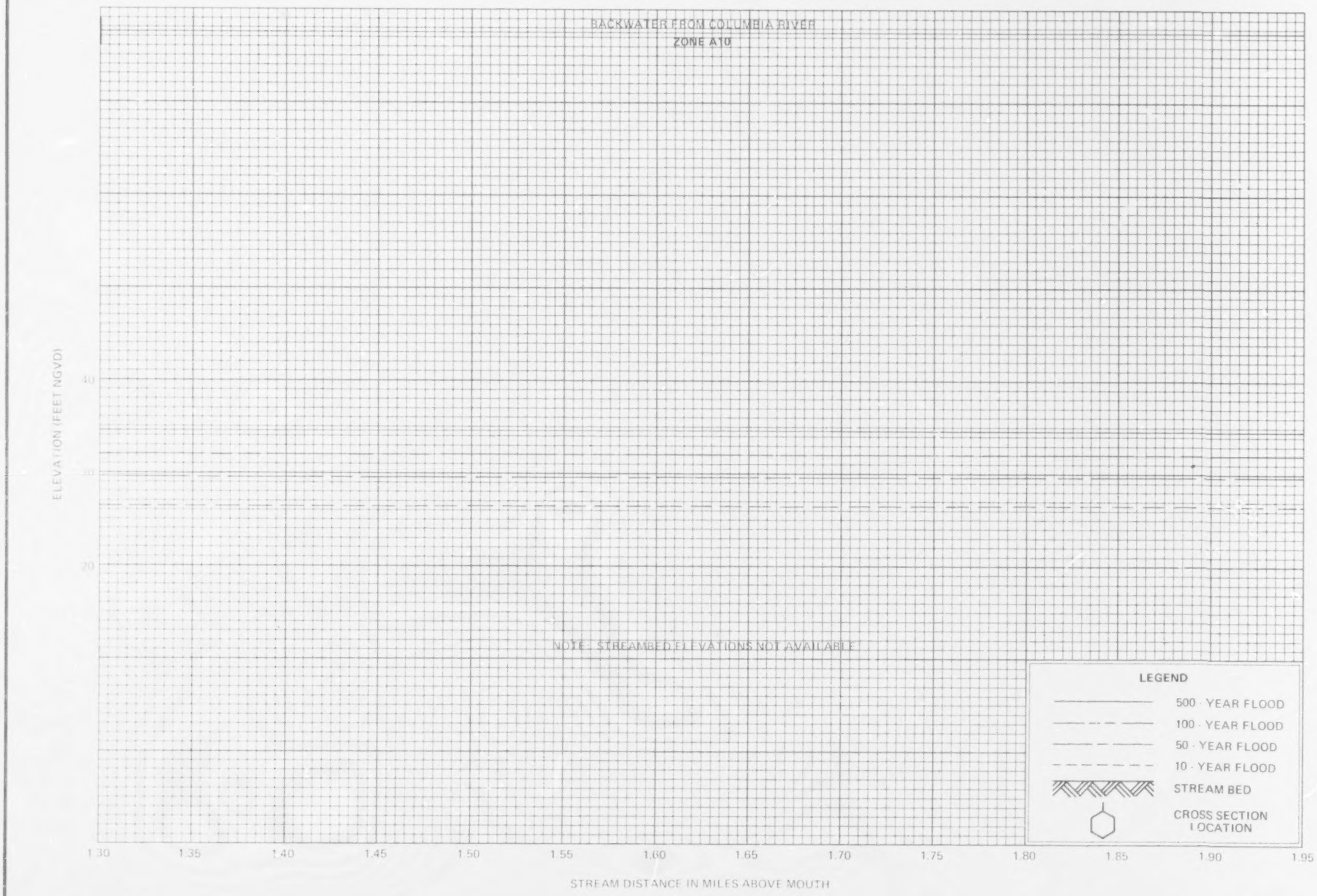

FLOOD PROFILES

SANDY RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO, OR
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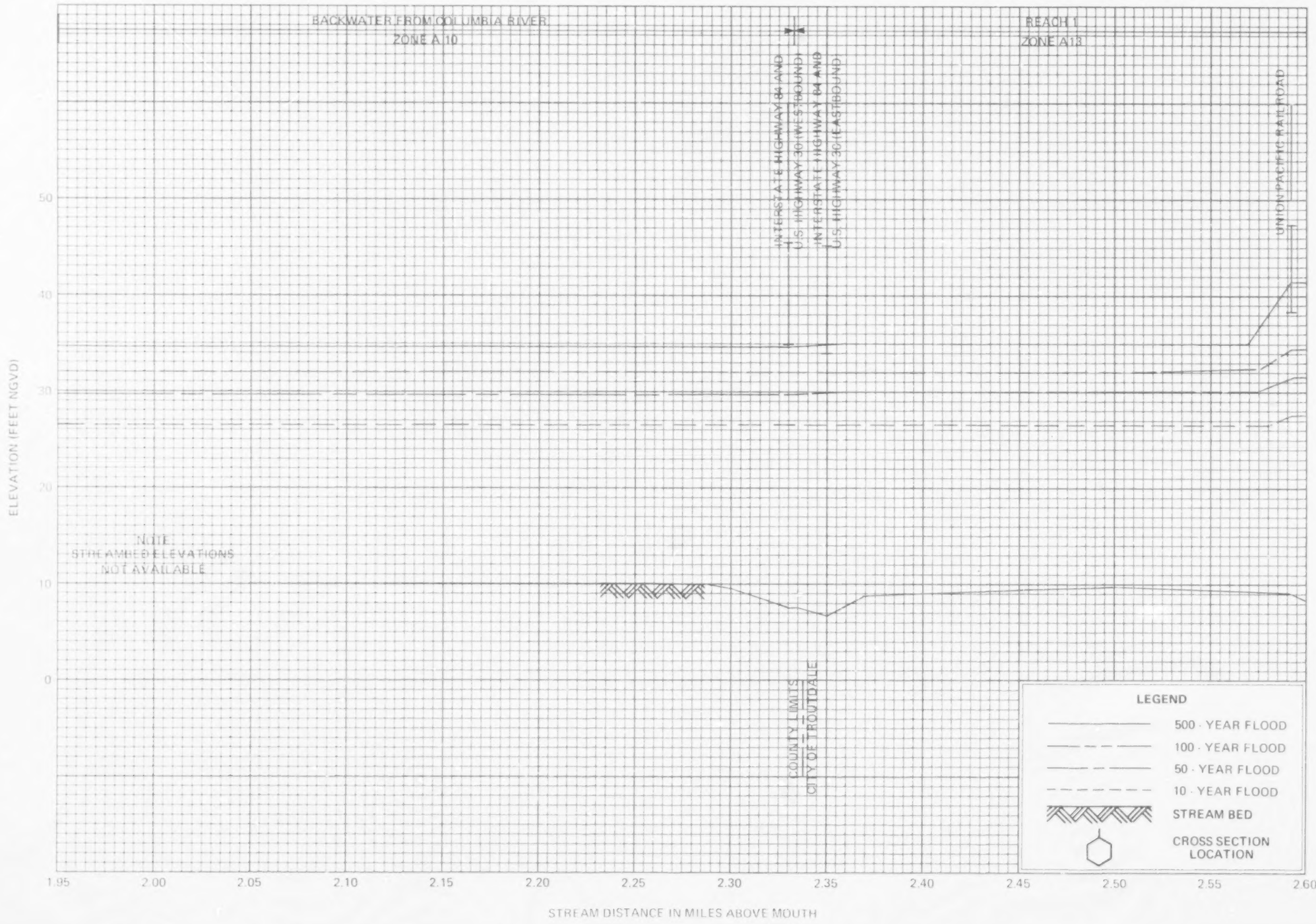

FLOOD PROFILES

SANDY RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO., OR
(UNINCORPORATED AREAS)

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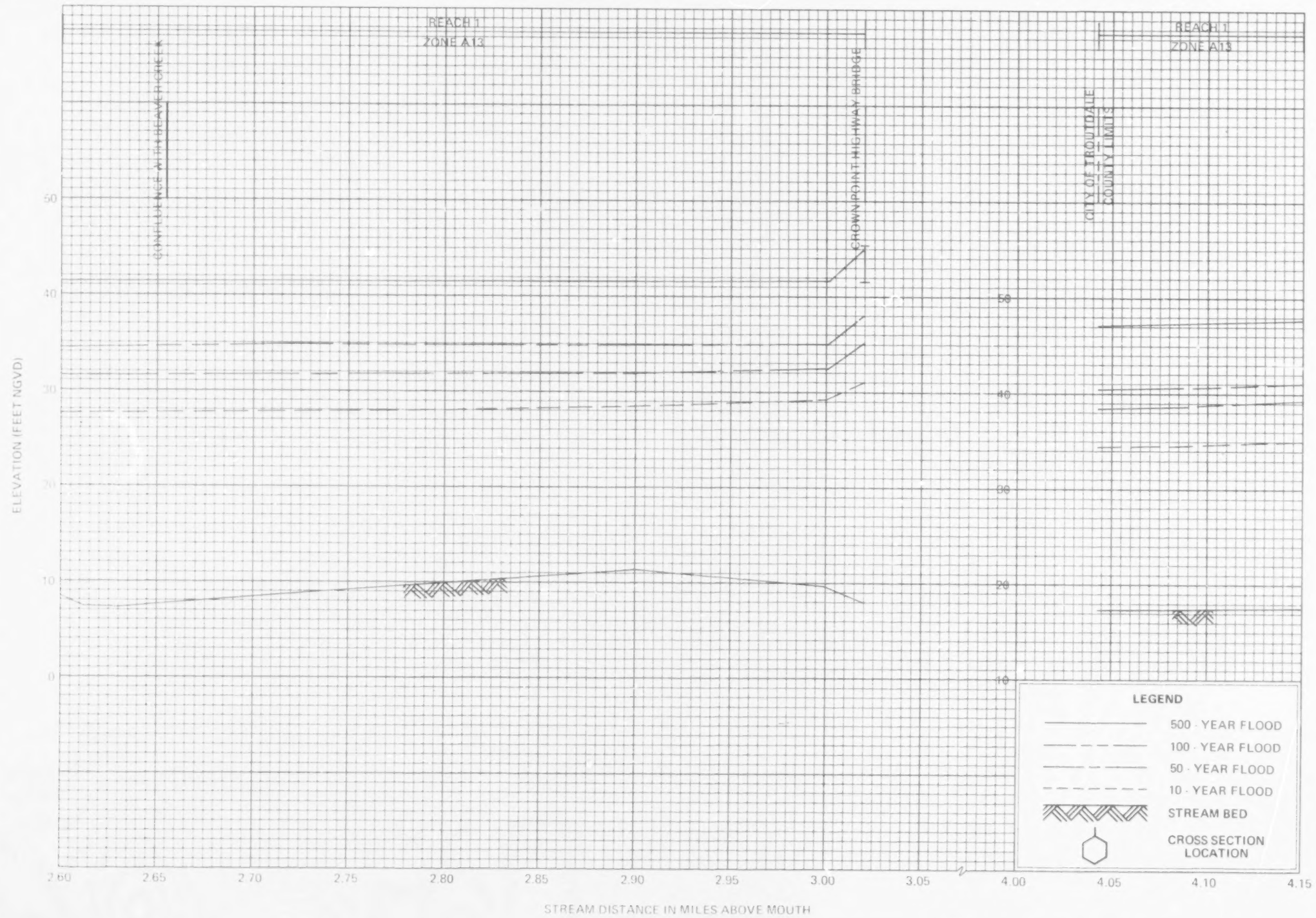

FLOOD PROFILES

SANDY RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO, OR
(UNINCORPORATED AREAS)

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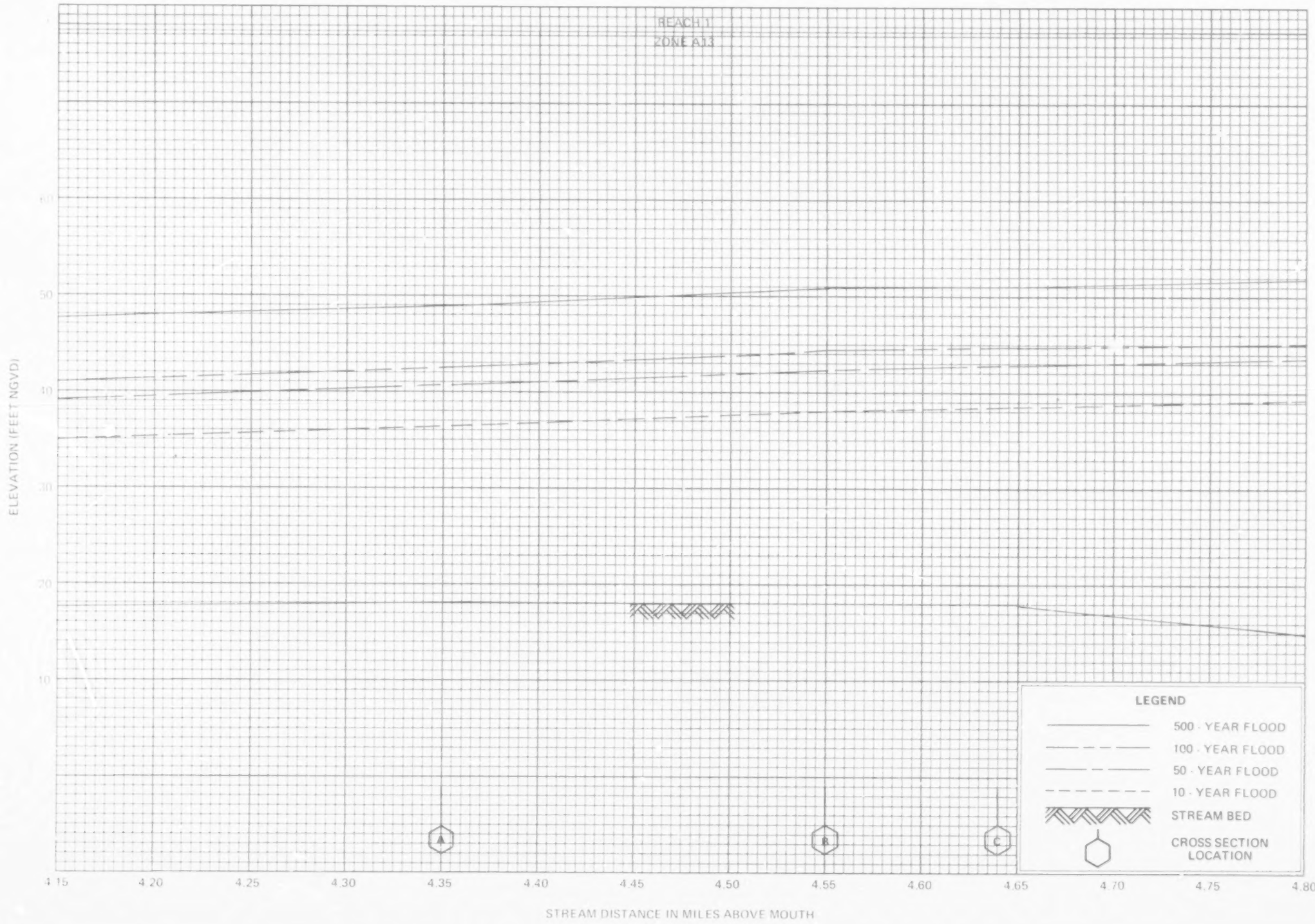

FLOOD PROFILES

SANDY RIVER

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MULTNOMAH CO., OR
(UNINCORPORATED AREAS)

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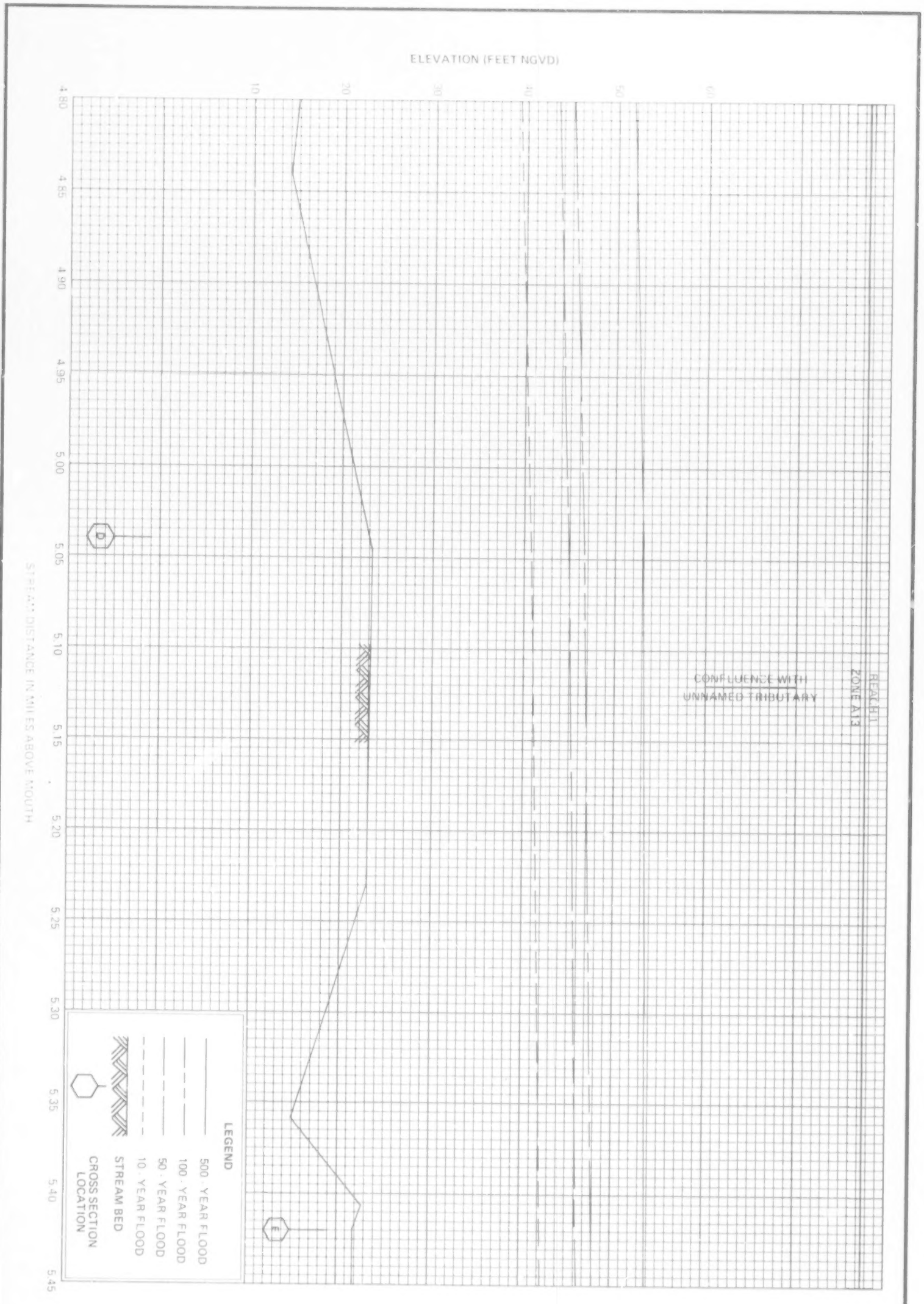

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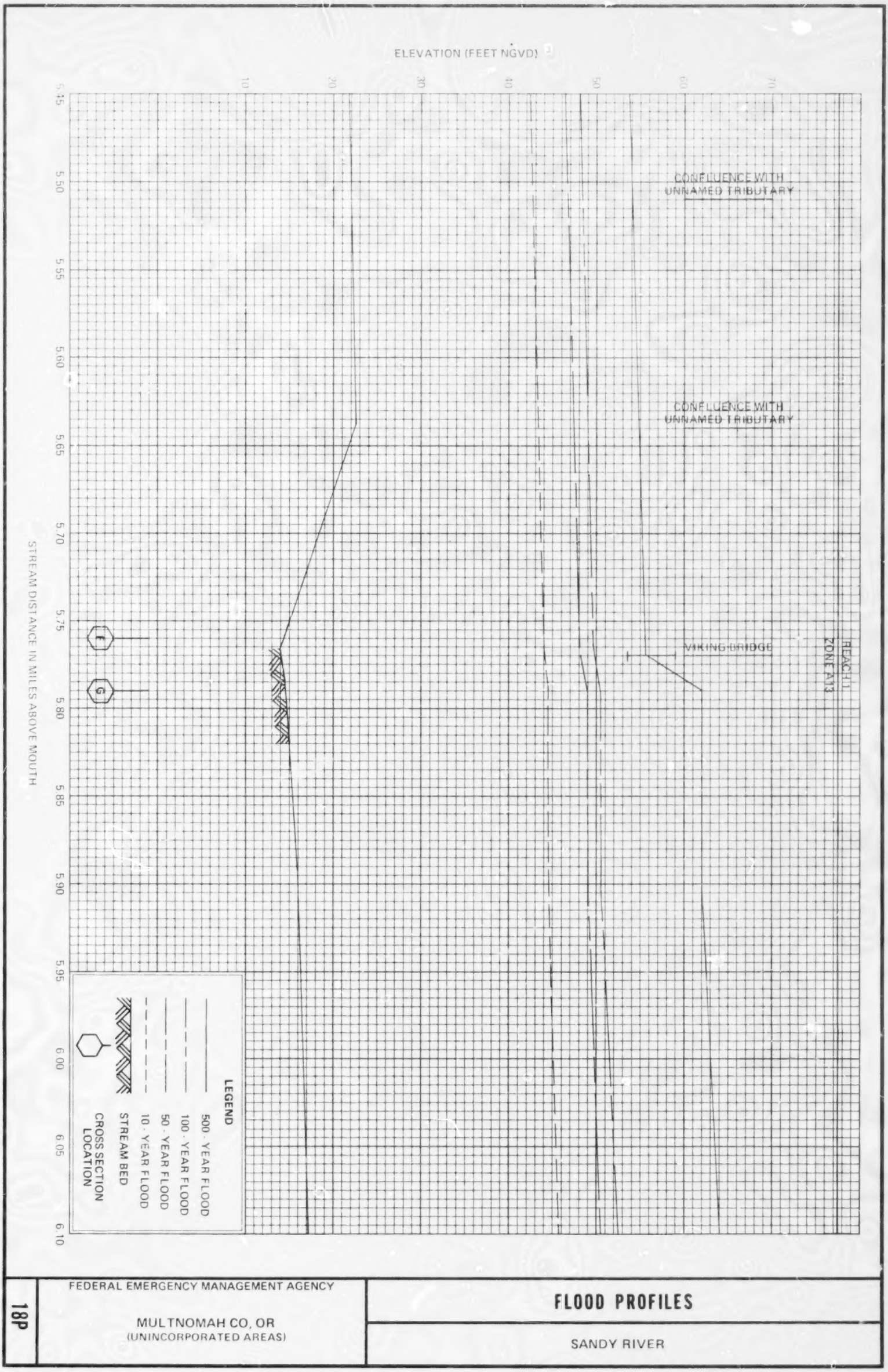

18P	FEDERAL EMERGENCY MANAGEMENT AGENCY MULTNOMAH CO, OR (UNINCORPORATED AREAS)	FLOOD PROFILES SANDY RIVER

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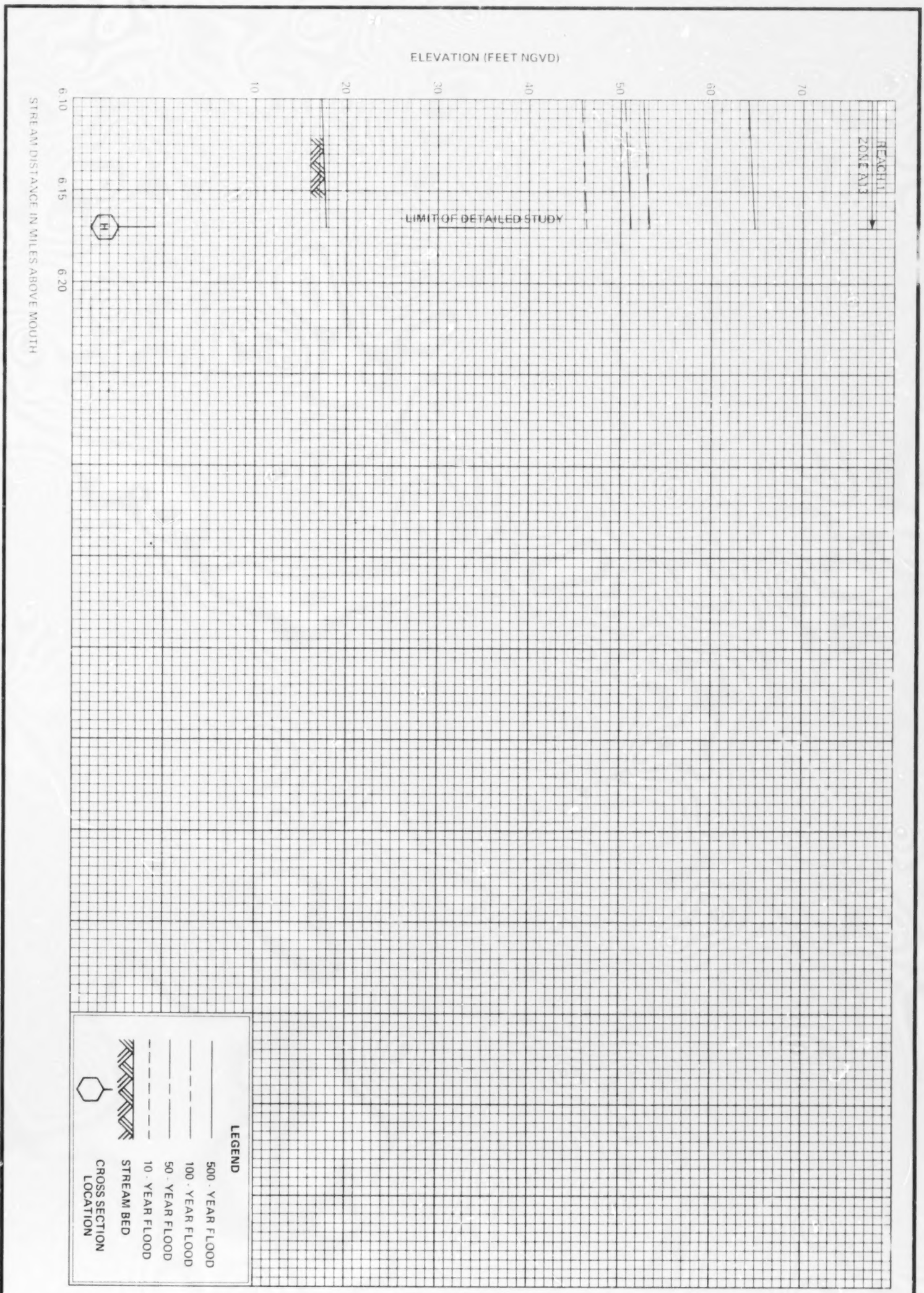

19P	FEDERAL EMERGENCY MANAGEMENT AGENCY MULTNOMAH CO, OR (UNINCORPORATED AREAS)	FLOOD PROFILES SANDY RIVER

59

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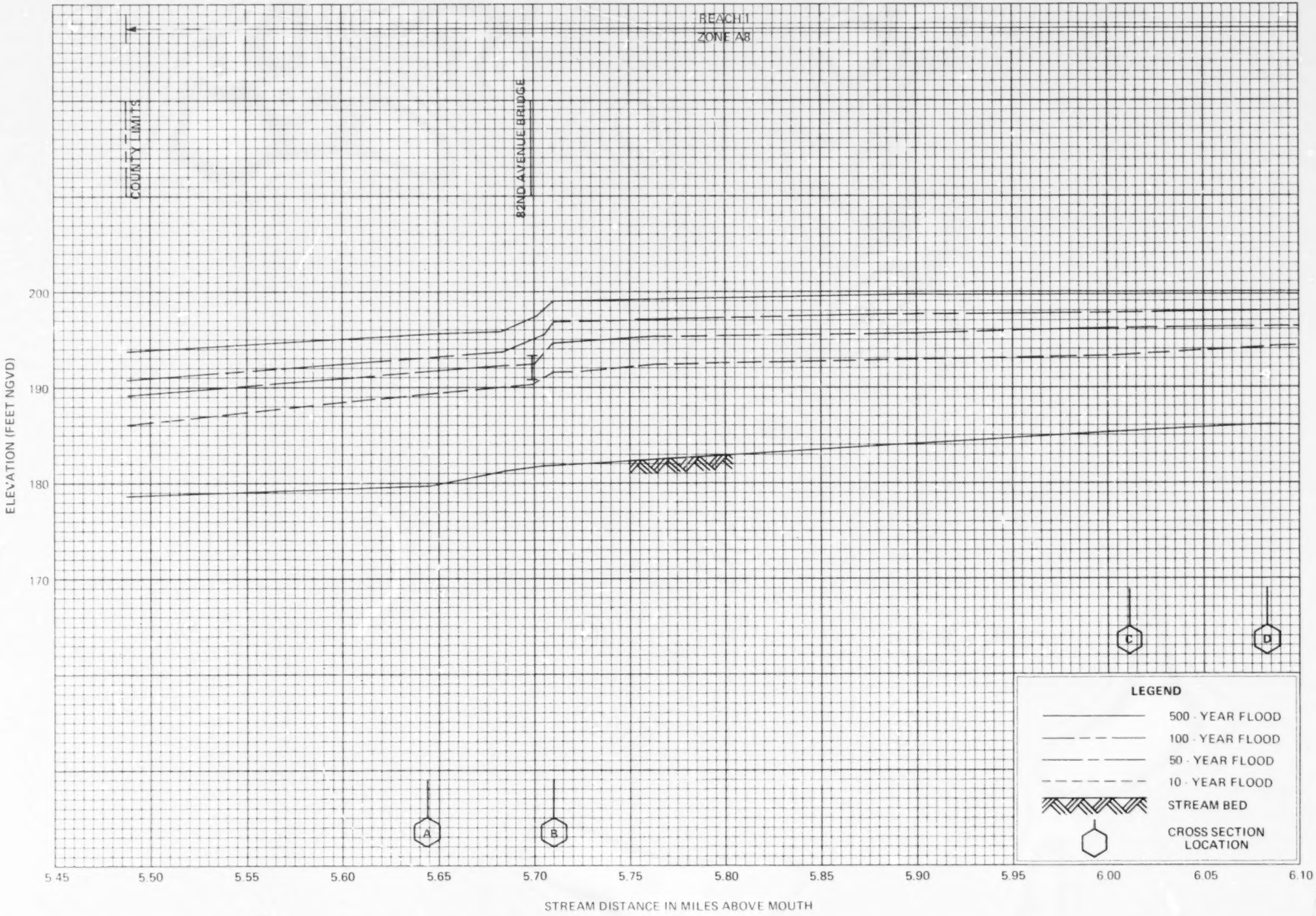

FLOOD PROFILES

JOHNSON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO, OR
(UNINCORPORATED AREAS)

20P

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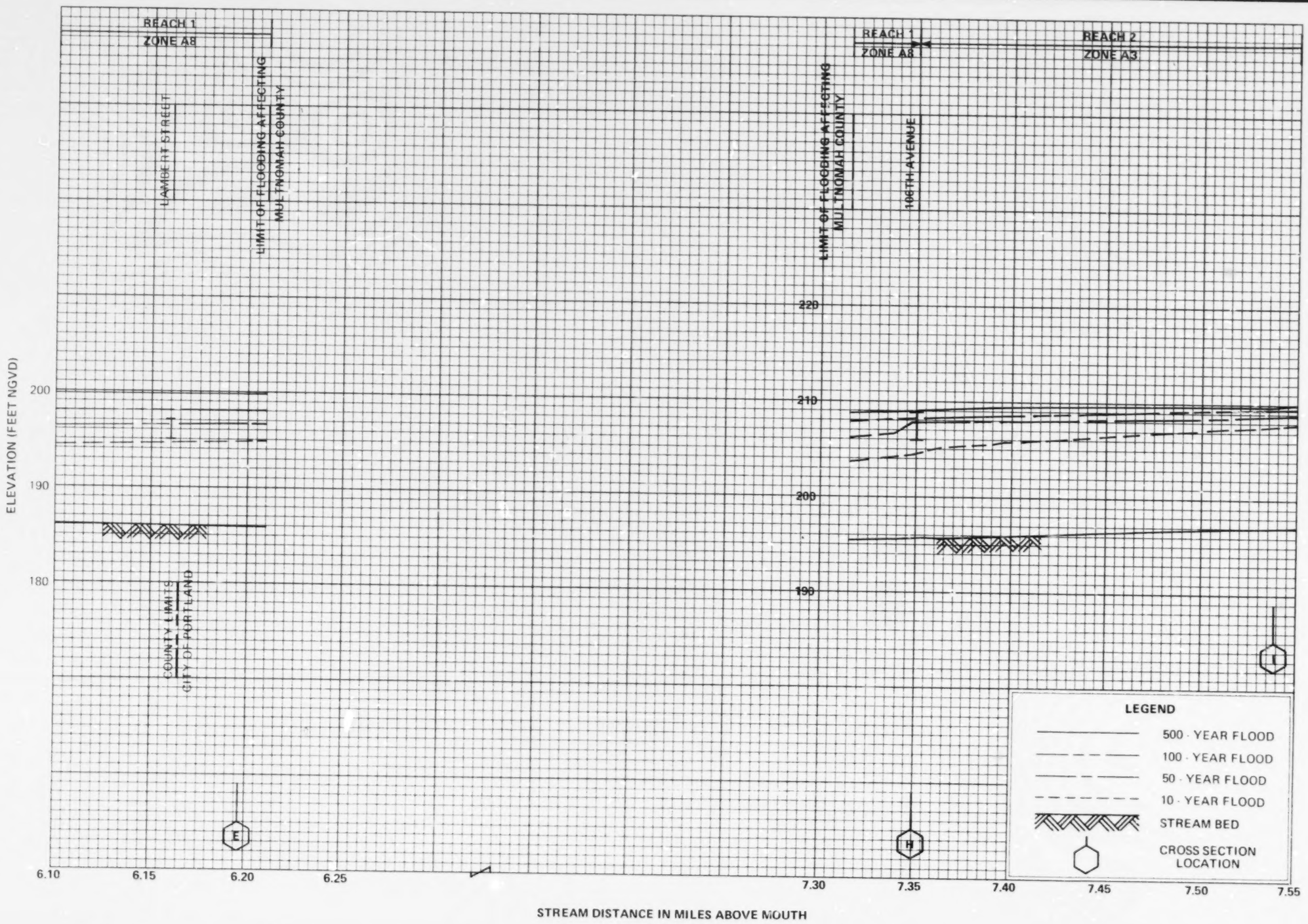

FLOOD PROFILES

JOHNSON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO, OR
(UNINCORPORATED AREAS)

21P

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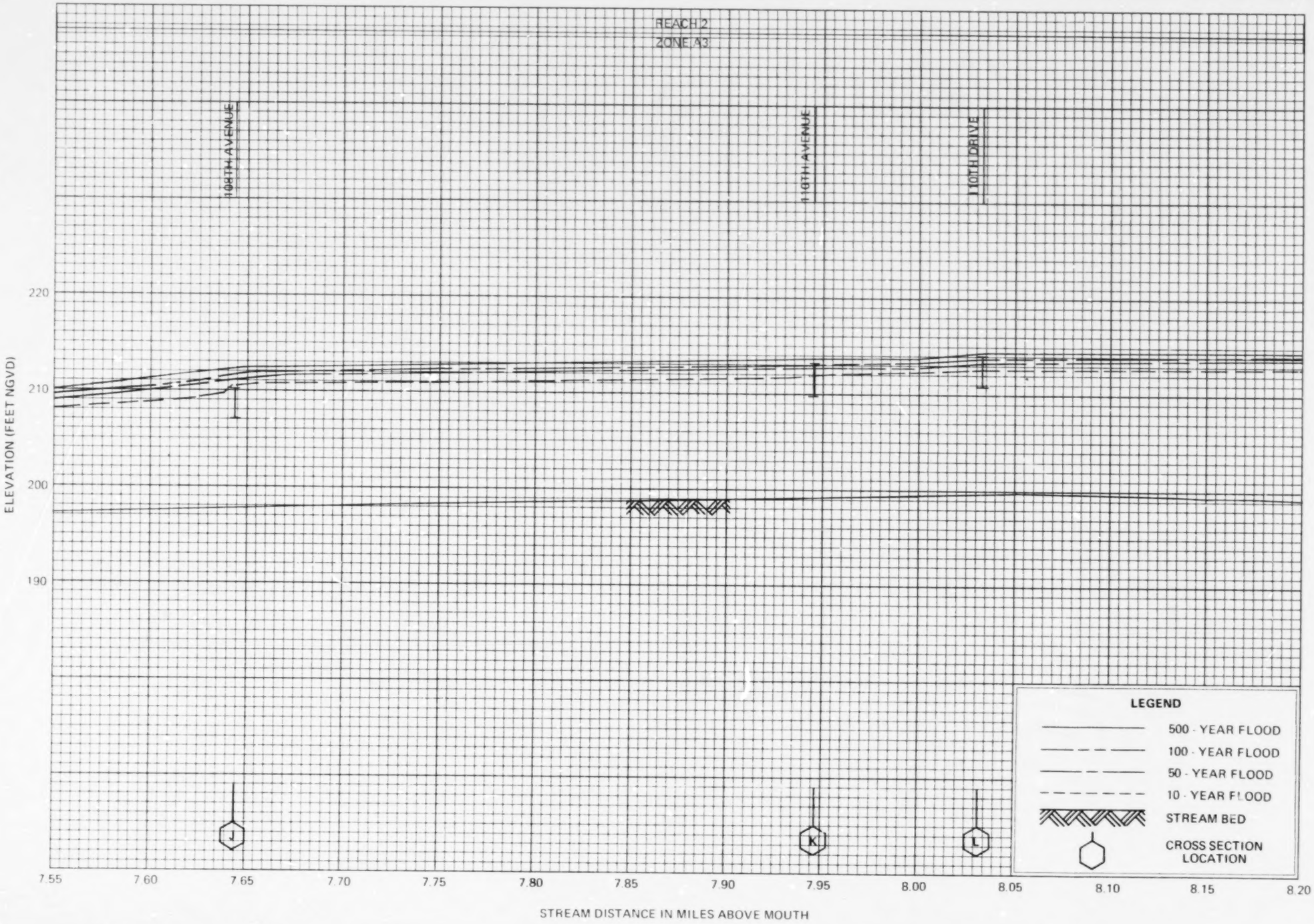

FLOOD PROFILES

JOHNSON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO, OR
(UNINCORPORATED AREAS)

22P

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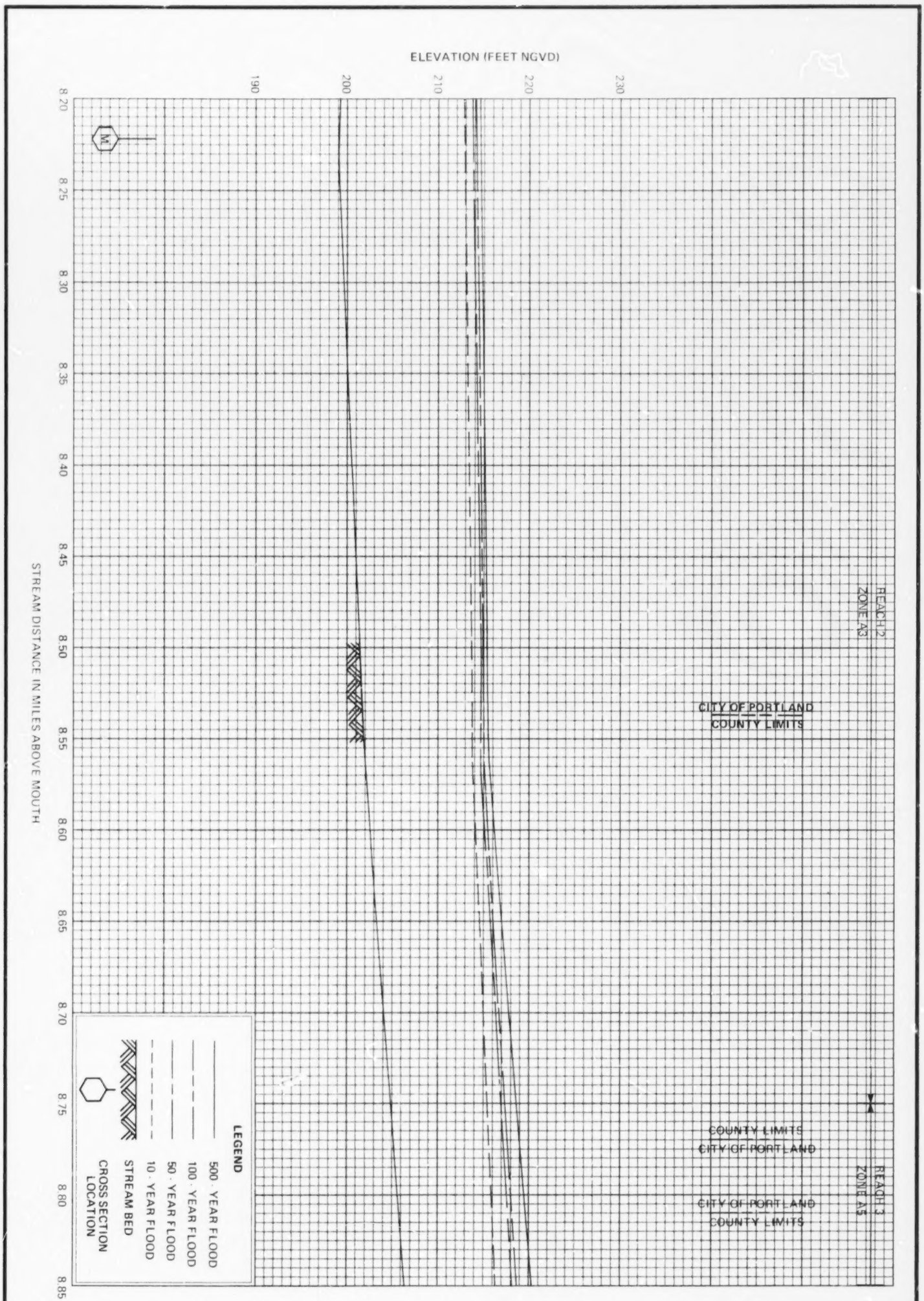
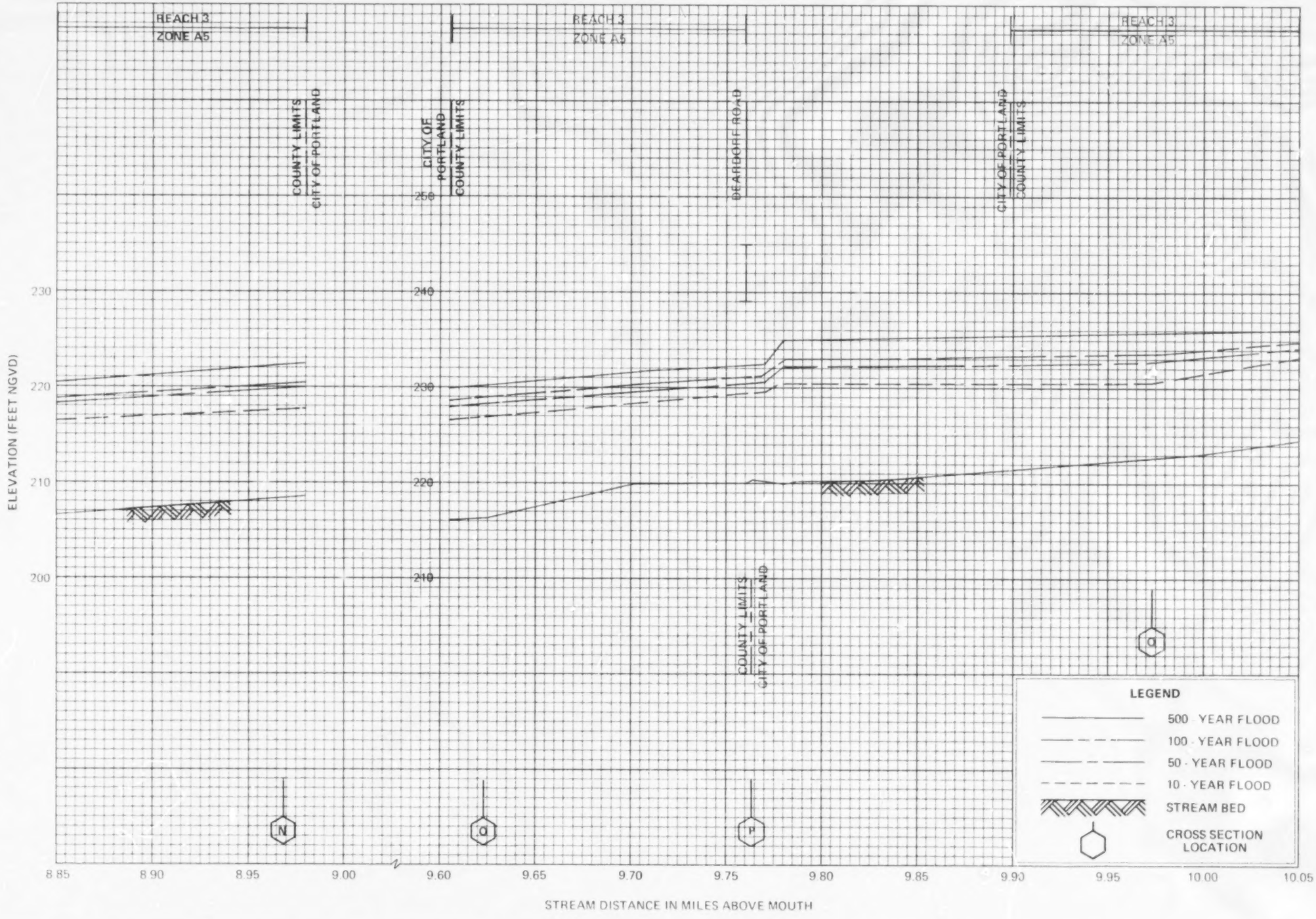


23P	FEDERAL EMERGENCY MANAGEMENT AGENCY MULTNOMAH CO, OR (UNINCORPORATED AREAS)	FLOOD PROFILES JOHNSON CREEK

BEST COPY AVAILABLE



FLOOD PROFILES

JOHNSON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO, OR
(UNINCORPORATED AREAS)

24P

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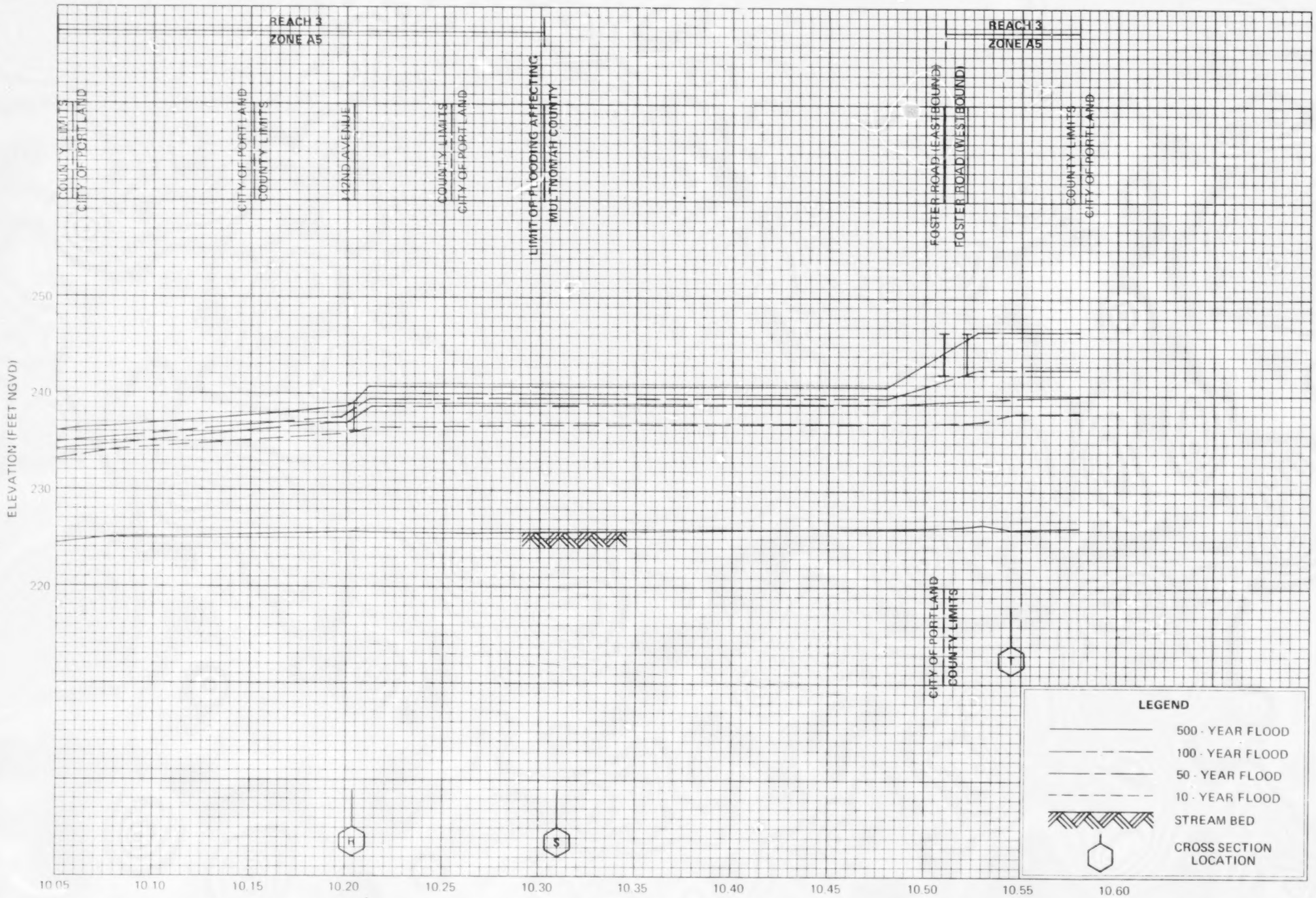

FLOOD PROFILES

JOHNSON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO, OR
(UNINCORPORATED AREAS)

25P

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REACH 13
ZONE A5

CIRCLE AVENUE BRIDGE
PORTLAND TRACTION COMPANY RAILROAD BRIDGE

CITY OF PORTLAND COUNTY LIMITS

ELEVATION (FEET NGVD)

260
250
240
230

11.60 11.65 11.70 11.75 11.80 11.85 11.90 11.95 12.00 12.05 12.10 12.15 12.20 12.25

STREAM DISTANCE IN MILES ABOVE MOUTH

U V W X Y

LEGEND

- 500 - YEAR FLOOD
- 100 - YEAR FLOOD
- 50 - YEAR FLOOD
- 10 - YEAR FLOOD
- STREAM BED
- CROSS SECTION LOCATION

FLOOD PROFILES

JOHNSON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO, OR
(UNINCORPORATED AREAS)

26P

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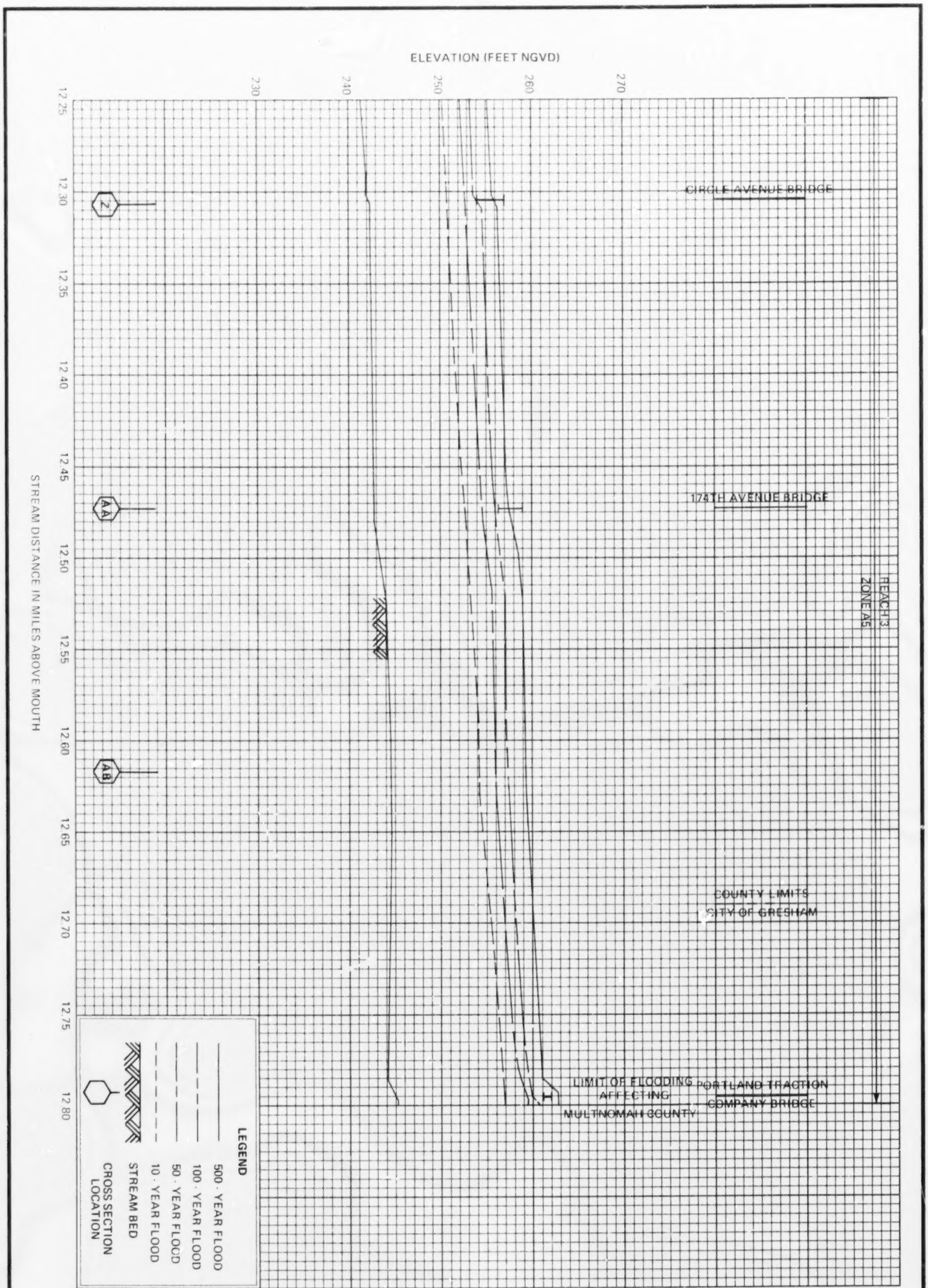

27P	FEDERAL EMERGENCY MANAGEMENT AGENCY MULTNOMAH CO, OR (UNINCORPORATED AREAS)	FLOOD PROFILES JOHNSON CREEK

67

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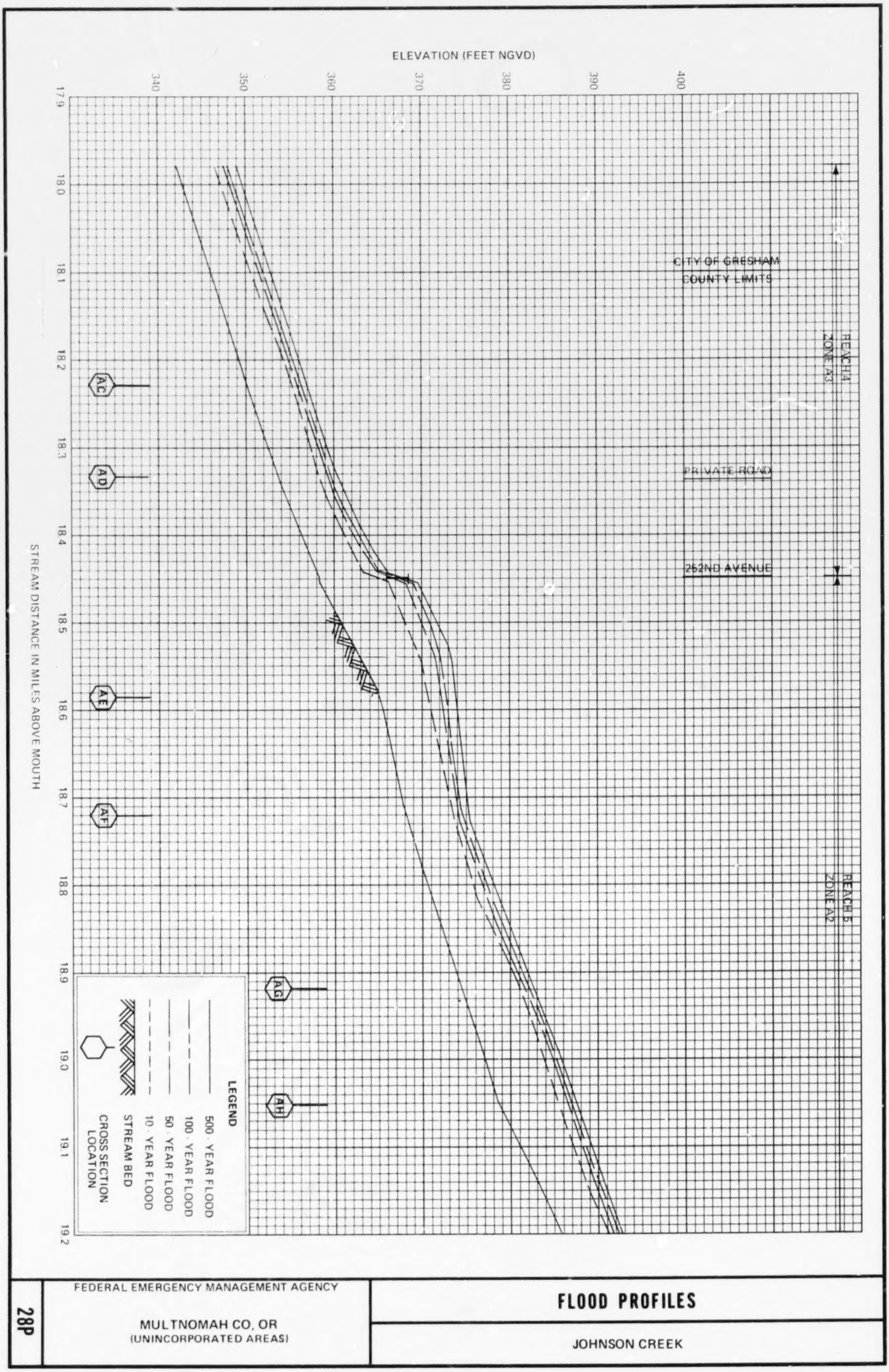

28P	FEDERAL EMERGENCY MANAGEMENT AGENCY MULTNOMAH CO, OR (UNINCORPORATED AREAS)	FLOOD PROFILES JOHNSON CREEK

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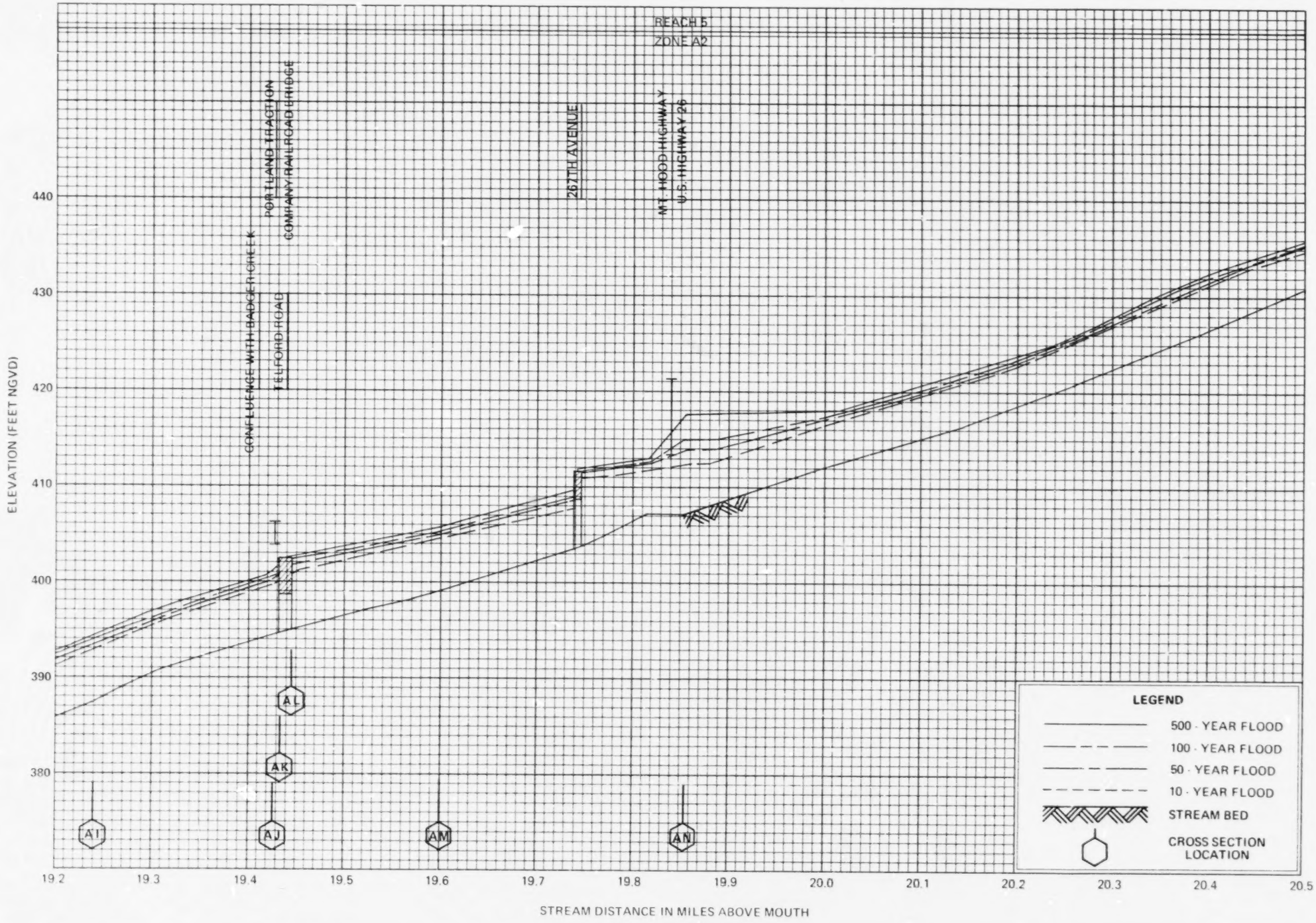

FLOOD PROFILES

JOHNSON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO, OR
(UNINCORPORATED AREAS)

29P

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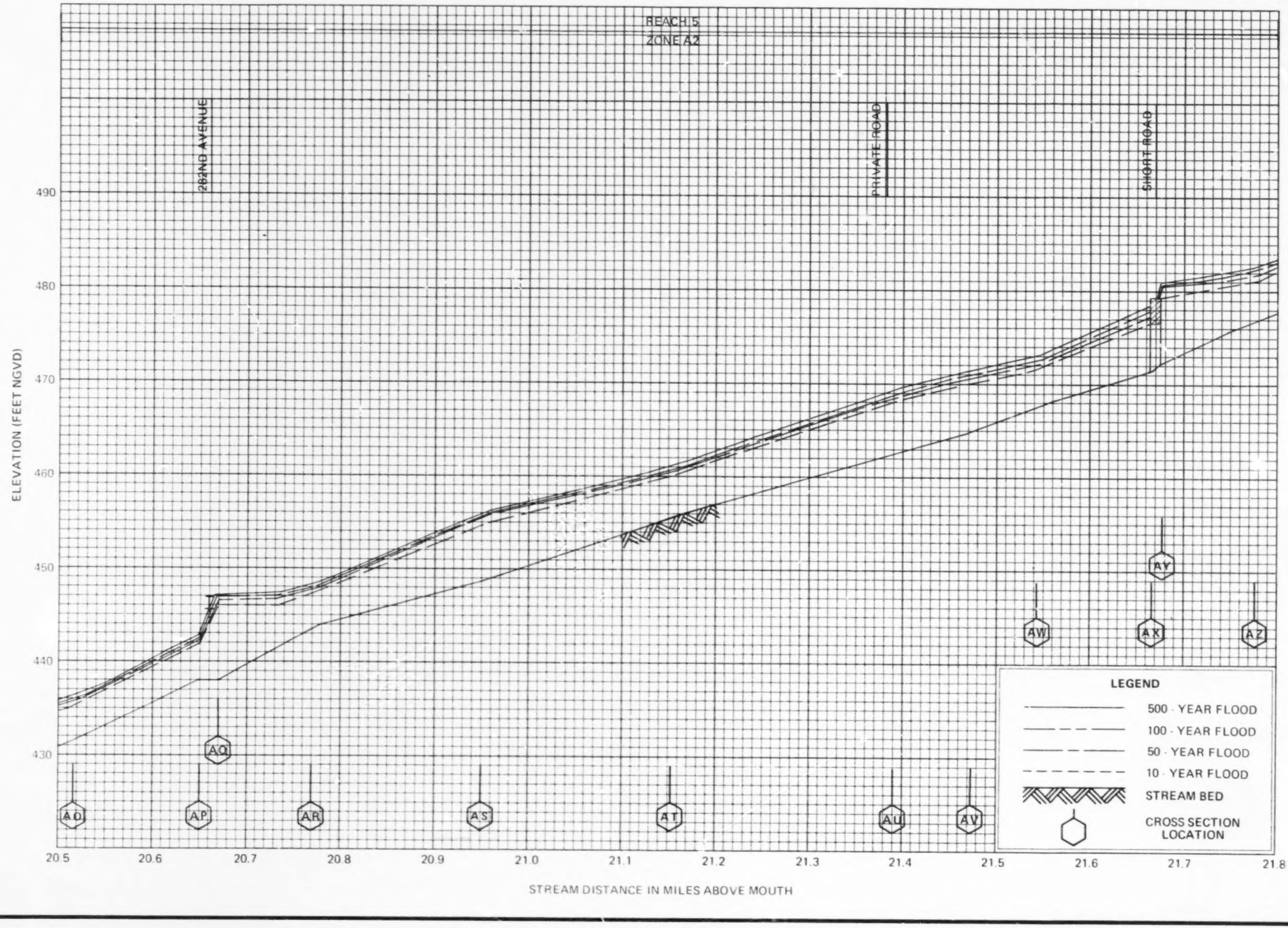

FLOOD PROFILES

JOHNSON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO, OR
(UNINCORPORATED AREAS)

30 P

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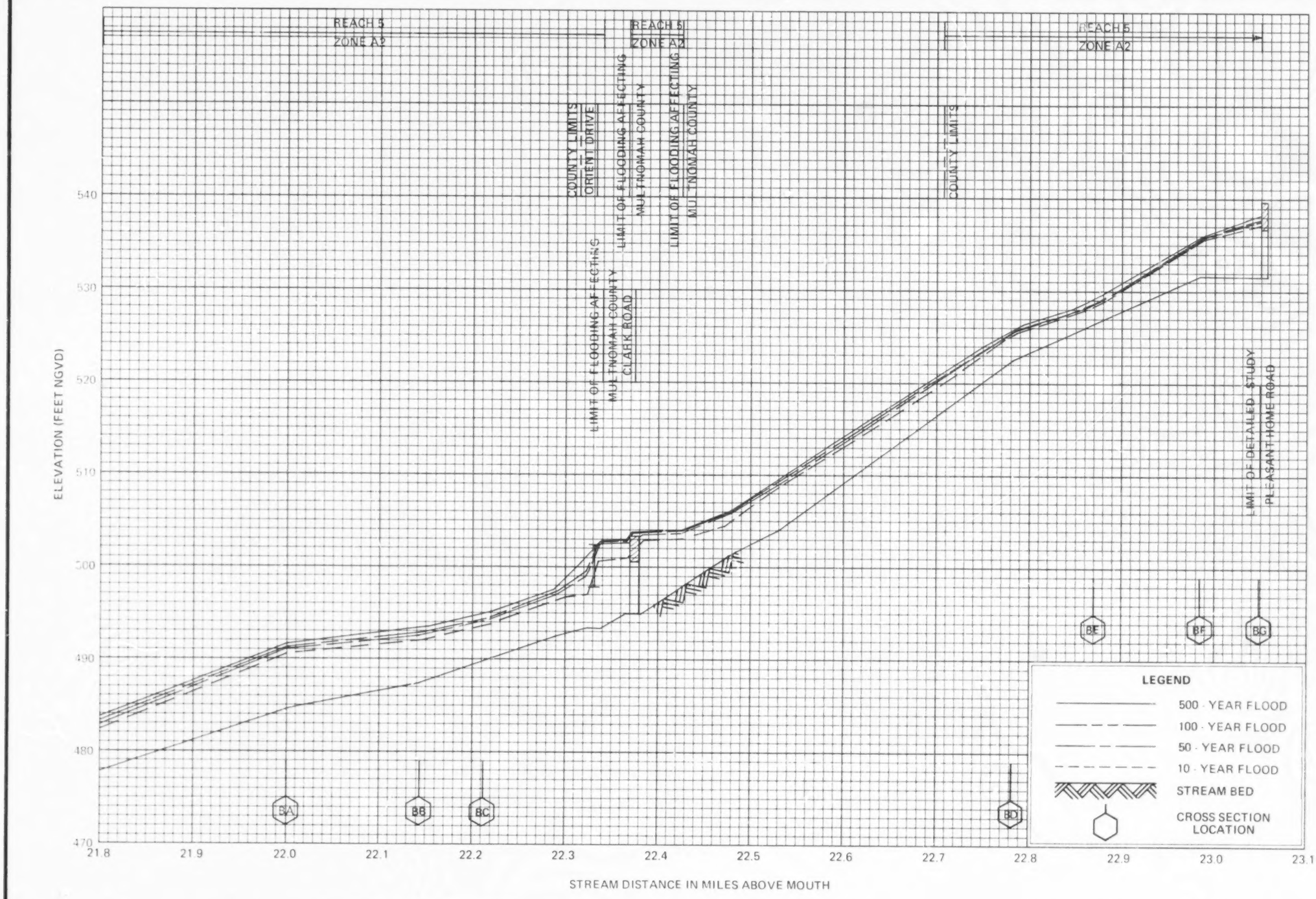

FLOOD PROFILES

JOHNSON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH CO, OR
(UNINCORPORATED AREAS)

31P

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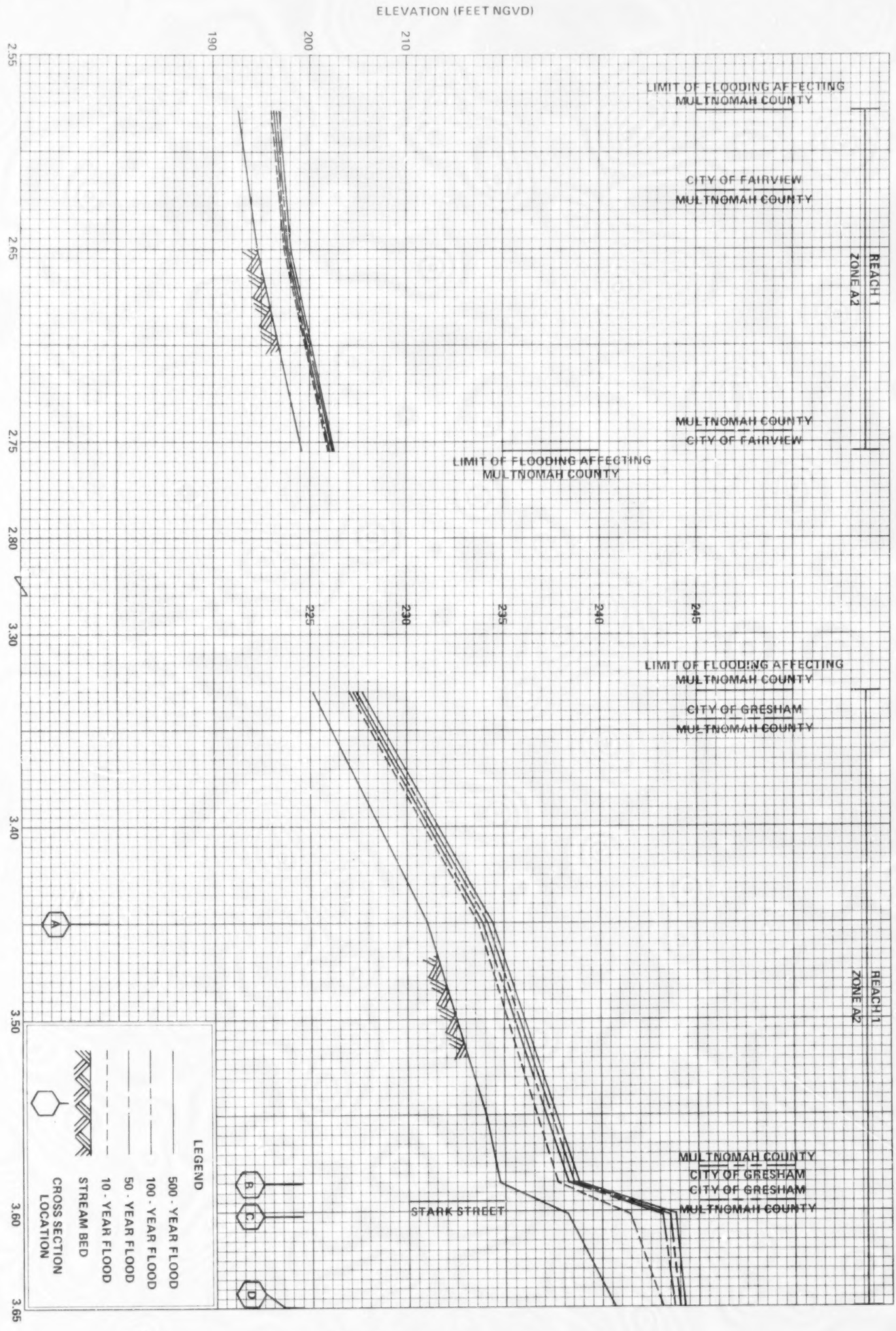

32P	FEDERAL EMERGENCY MANAGEMENT AGENCY MULTNOMAH COUNTY, OR (UNINCORPORATED AREAS)	FLOOD PROFILES FAIRVIEW CREEK

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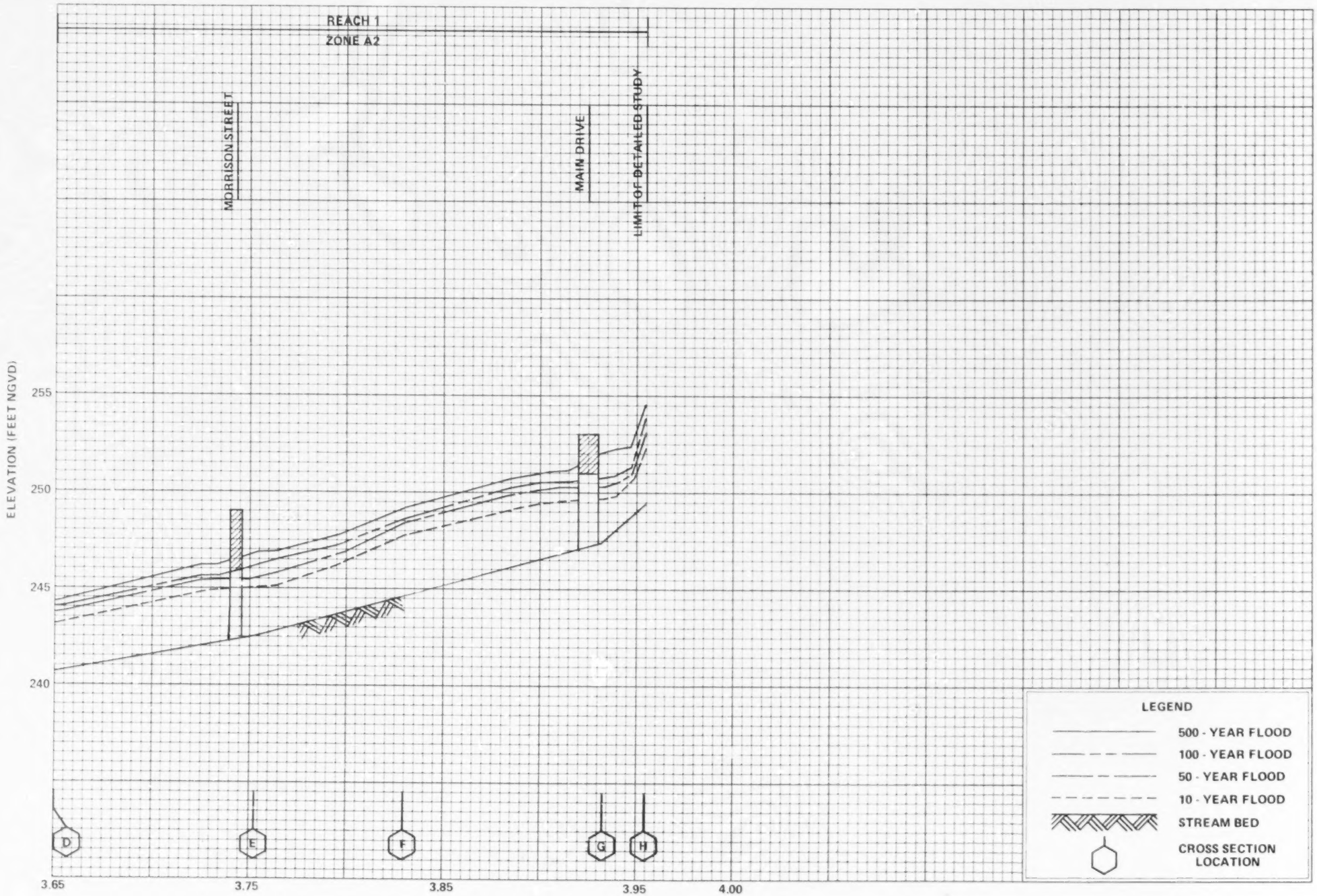


FLOOD PROFILES

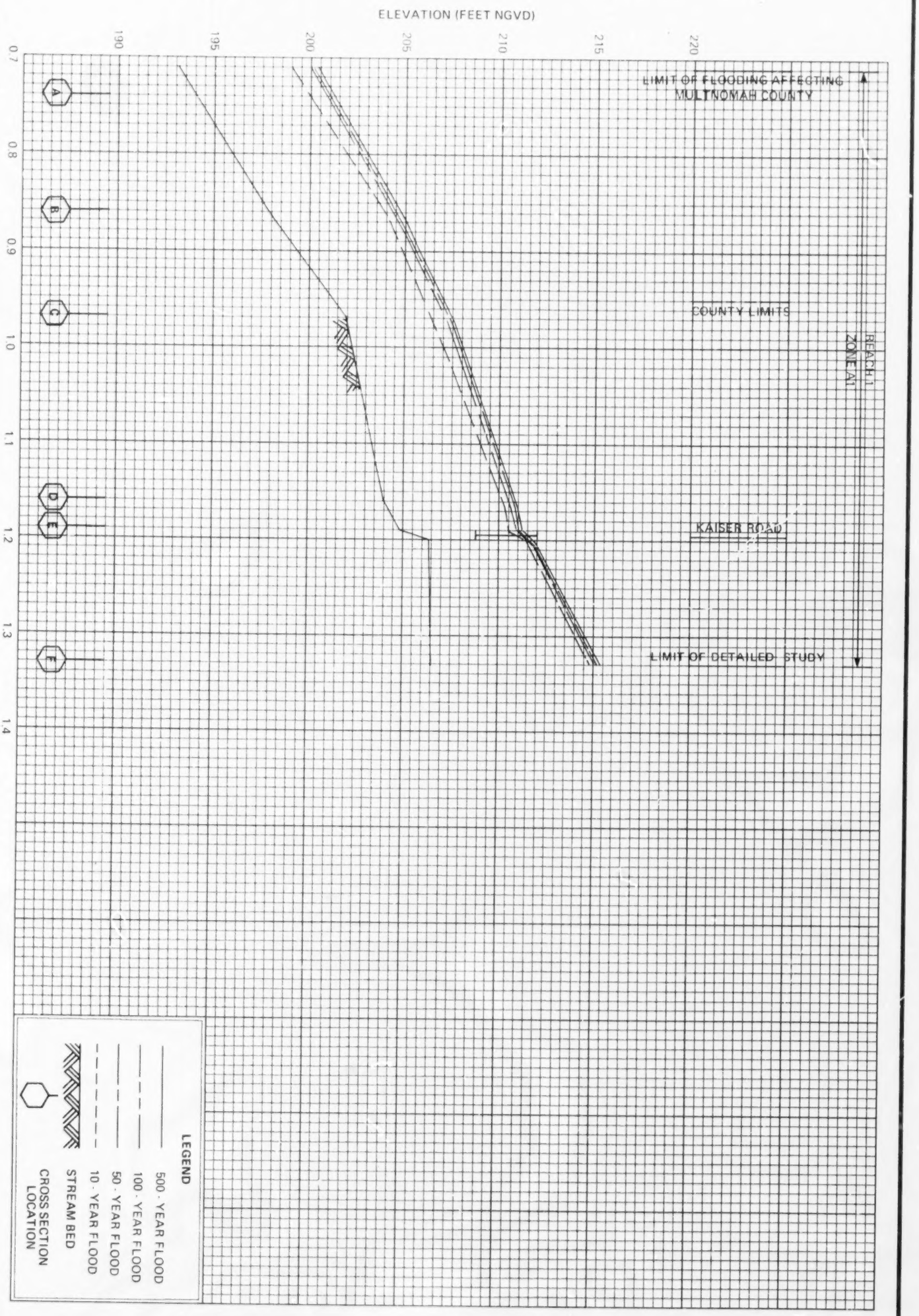
FAIRVIEW CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTNOMAH COUNTY, OR
(UNINCORPORATED AREAS)

33P

BEST COPY AVAILABLE



74

34P	FEDERAL EMERGENCY MANAGEMENT AGENCY MULTNOMAH CO, OR (UNINCORPORATED AREAS)	FLOOD PROFILES UNNAMED TRIBUTARY TO ROCK CREEK

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